TECHNO – ECONOMIC AND ENVIRONMENTAL ASSESSMENT OF WASTE-TO-ENERGY DEVELOPMENT IN NIGERIA, 1981 - 2017

BY

Opeyemi Anthony **AMUSAN**

(Matric. No.: 87913)

B.Sc. Hons Mechanical Engineering (Ibadan), M.Sc. (Bonn) Agric. Engr. Sciences & Resources Management, FCSP, FIMCB, FSHCM, FRWESK, CSAE, MASME, MNSE, MSPE, MNImechE, PMP, SBDP, MDWA, MIAHS, CAI, MNgNOG, COREN Regd.

A Thesis in the Department of Mineral, Petroleum, Energy Economics and Law (DMPEEL)
Submitted to the Faculty of Multidisciplinary Studies in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY
of the
UNIVERSITY OF IBADAN

JULY, 2023

CERTIFICATION

I certify that this work was carried out by Engr. O. A. Amusan in the Department of Mineral, Petroleum, Energy Economics and Law, University of Ibadan.

....

Supervisor
A. F. Adenikinju
B. Sc., M. Sc., Ph.D. (Ibadan), FNAEE, FIE
Professor, Departments of Economics / Mineral, Petroleum, Energy Economics & Law
University of Ibadan, Nigeria

....

Co - Supervisor
J. A. Omojolaibi
B.Sc., (Jos), M. Sc., Ph.D. (Ibadan)
Associate Professor, Department of Mineral, Petroleum, Energy Economics & Law
University of Ibadan, Nigeria

....

Co - Supervisor
R.A. Atinga
B.Sc., M. Sc., Ph.D. (Legon)
Senior Lecturer, Department of Public Administration & Health Management Services
University of Ghana, Legon, Ghana

DEDICATION

I dedicate this doctorate (PhD) research work to my children Ebunoluwa Joan Amusan, Iyanuoluwa John Amusan, Aanuoluwa Joel Amusan and Monjolaoluwa Joy Amusan.

You are my motivation and very special to the Amusan clan. I want to use this to encourage you to keep the flame of our noble family burning brightly in your generation and sustainably pass it on to the ones (generations) after you. May the Almighty God make you eternal excellency, joy of many generations in Jesus' name (Amen).

ACKNOWLEDGEMENTS

My special thanks goes to Prof. Akin Iwayemi, Prof. Justice Bawole, Prof. Hellwig, Prof. Kwame Asamoah, Prof. Albert Ahenkan, Dr. Pascal Anosike, Dr. Amsalu Kesete, Dr. Joseph Essandoh-Yeddu, supervisors Prof. Adeola Adenikinju, Dr. Joseph Omojolaibi, and Dr. Roger Atinga for their advice and encouragement throughout my doctorate (PhD) study.

I thank my darling wife Mrs. Olusola Aduke Amusan for her patience and understanding throughout the study and for her good care of the family. To my loving children – Ebunoluwa Amusan, Iyanuoluwa Amusan, Aanuoluwa Amusan and Monjolaoluwa Amusan, I say a big thank you for highly appreciated support and understanding throughout this doctorate (PhD) degree journey. I lack the words to adequately acknowledge and convey my deep sense of gratitude to my dear father, Pastor Tony Amusan for his invaluable assistance and suggestions during the field studies, and to my dear mother, Mrs. Agnes Amusan as well as my siblings and their family members for their moral support. I am highly indebted to Mr. Prosper Ayande, Mr. Simon Saskyi, Mr. Mark Akpewo, Mr. Kofi Boateng, Ms. Marleen (Safisana), Mr. Gabriel Anawe, Miss. Mercy Orukpe, Mr. Oladeji, Mr. Felix Yeboah, Mr. Peter, Mr. Matthew, Mr. Ennisson, Mr. Muizz Adio, Mr. David Oriyomi and Mr. Olalekan Owojori for their assistance in administering the questionnaires and organization of the expert workshops, Prof. & Dr. (Mrs.) Agulana, Prof. Amosu, Prof. Codjoe, Dr. Diji, Dr. Olarewaju, Dr. K.O Obisesan, Prof. Dare, Prof. Odesola, Dr. Yaw Asare-Osei, Dr. A. Adebayo, Mr. Soji Adisa, Dr. Fashoghon, Dipl. Ing. Amusan, Dr. Peterseim, Dipl. Ing. Dinkler, Dipl. Ing. Sharma, Prof. Simolowo, Dr. Tiyamiyu and Dr. Oladele M.B (UNILAG) for the brotherly and professional support given me throughout my doctorate (PhD) Programme.

My special thanks also go to members of staff of the Ministry of Environment, Energy Commission of Nigeria, Ghana Energy Commission, Erkrohrkessel (ERK) Energy Systems GmbH, Association of Waste Managers of Nigeria (AWAMN), the Authors cited, International Institute for Tropical Agriculture (IITA, Ibadan), Zoomlion Ghana Limited, and the various Waste Management Agencies in Nigeria and Ghana, for linking me with relevant stakeholders and projects. I must also express my appreciation to Prof. Ogunjuyigbe, Prof. Falode, Prof. Olubusoye, Prof. Peter Obutte, Dr. Fadairo, Dr. Ajayi, Dr. Sesan and other CPEEL Faculties for their scholarly criticisms, which helped in restructuring this thesis. I remain very grateful to Dr. James Mensah, Mr. Daramola, Mrs. Mary, Dr. (Mrs.) Omotosho, Mrs. Blessing, Dr. Akinlabi, Dr. Obafemi, Dr. Mohammed-Noah, Engr. Essien, and other members of Staff and Students of the University of Ghana Business School and Center for Petroleum, Energy Economics & Law (CPEEL) for helping me to academically feel at home in Legon and Ibadan respectively. My sincere gratitude go to Pastor Williams Kumuyi (my Mentor), Pastor Enoch Adeboye, Reverend & Reverend (Mrs.) Ajetomobi, Pastor Ayo Afolabi, Dr. Stephen Afolayan (NIHORT, Ibadan), Pastor Tunrayo Alabi, Prof. & Dr. (Mrs.) Charles Amoatey, Dr. Israel Olasunkanmi, Dr. Jumoke Alabi, Mr. Moses Aworokun, Mrs. Ekundayo, Mr. Adisa, Mr. Akin, Mr. Akanji, Pastor &. Deaconess Israel Afolayan, and all the brethren in Nigeria, Germany and Ghana as well as to the Interviewees and Experts for giving me an insight into the practical situation of waste-to-energy / waste management in Nigeria and Ghana.

Finally, I thank the blessed Holy Trinity (God the Father, God the Son and God the Holy Spirit) for the successful completion of this work. Nothing could have been achieved without your mercy and divine guidance. “It pays to serve Jesus, I speak from my heart”.

ABSTRACT

Poor waste management in Nigeria results in environmental and socioeconomic problems. Managing wastes through the agelong approach of burning leads to climate change while landfill leachate reduces soil and ground water quality. Limited number of studies exist on the potential impact of managing wastes using waste-to-energy recovery generation (ReGen) technology in Nigeria and how waste-to-energy (WtE), environmental quality (EQ), and sustainable development (SD) are connected. Therefore, this study investigated the technoeconomic and environmental impact of using ReGen for waste management in Nigeria.

Environmental Kuznets Curve (EKC) hypothesis provided theoretical framework. Data on indicators of WtE in Nigeria were sourced from the World Development Indicators (1981-2017). These indicators include WtE, environmental footprint, green national net income, human development index, fossil energy consumption, per capita income, energy consumption, capital investment, urbanisation, trade intensity and land quality index. Augmented Dickey Fuller was used to ascertain the stationary of the variables specified in the model. The bound test was preferred based on the stationary of variables at level and at difference. Since the variables are cointegrated at difference order, the secondary time series methodology described as Autoregressive Distributive Lag (ARDL) was used to estimate the short and long run relationship of the model. Thus, the relationship among WtE, EQ and SD was analysed using ARDL technique at $\alpha_{0.05}$. The bound test was used to test for cointegration among the study variables. Technoeconomic viability of ReGen was evaluated with Cost Benefit Analysis.

Values of the bound tests (F-Statistics) stood at 19.23 and 5.64 which are above the upper critical values of 4.76 and 3.83 respectively at 5% p-value. This showed that there is cointegration indicating the presence of both short and long run relationship. The coefficient of 5.02 implies a positive relationship between WtE and EQ, that is, a 1% increase in WtE, leads to 5.02kt increase in EQ. The coefficient of −1.25 indicates inverse relationship between WtE and SD, which means, a 1% increase in WtE, reduces SD by 1.25kt. The WtE significantly drove EQ and SD. Though in 2017, WtE affected EQ and SD negatively, however it translates to positive development in the long run. EQ and energy consumption exhibit positive relationship in the short to long run. The existence of EKC hypothesis in Nigeria was established, which contributed to environmental degradation at the early stage and declined with increasing economic growth in the latter stage. The generating cost of ReGen electricity was $0.71/kWh with 6-8 years payback period and better environmental socioeconomic benefits than equivalent diesel generators. The ReGen reduced waste by 90.0% with 332 kW net energy output from 980 kg waste/hour.

The technoeconomic and environmental assessment of waste-to-energy enhanced environmental quality and sustainable development between 1981 and 2017 in Nigeria. The use of waste-to-energy recovery as a technology for solving waste management problems is adequate, economical and environmentally viable. Government should provide enabling environment for increased investment in waste-to-energy recovery generation.

Keywords: Environmental kuznets curve, Environmental quality, Recovery generation technology, Waste management, Waste-to-Energy

Word count: 479

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NOMENCLATURE

Abbreviations and Symbols

1.	WtE	–	Waste-to-Energy
2.	EKC	–	Environmental Kutznets Curve
3.	ReGen	–	Waste-to-Energy Recovery Generation
4.	MSWM	-	Municipal Solid Waste Management
5.	WEC	–	World Energy Council
6.	UNEP	–	United Nations Environmental Protection
7.	FDI	–	Foreign Direct Investment
8.	UN	–	United Nations
9.	UNDP	–	United Nations Development Program
10.	IITA	–	International Institute for Tropical Agriculture
11.	ERK	-	Eckrohrkessel
12.	GCF	–	Gross Capita Formation
13.	CBA	–	Cost Benefit Analysis
14.	ARDL	–	Autoregressive Distributive Lag
15.	DISCOS	–	Distribution Companies
16.	SW / SW	-	Nigeria – Southwestern / Southwestern Nigeria
17.	LAWMA	–	Lagos State Waste Management Agency
18.	LAB	–	Human Capital Development Index (HDI)
19.	PSP	–	Private Service Public / Private Sector Partnership
20.	AWAMN	–	Association of Waste Managers of Nigeria
21.	GDP	–	Gross Domestic Product
22.	EES	–	Economic, Environment and Social
23.	US	–	United States
24.	CO_2	–	Carbon dioxide
25.	GDPC	–	Gross Domestic per Capita
26.	EXC	–	Exchange Rate
27.	WTE	–	Combustible Renewable and Waste
28.	₦	-	Naira
29.	ANSEPA	-	Anambra State Environmental Protection Agency
30.	SDGs	-	Sustainable Development Goals
31.	OLS	-	Ordinary Least Squares
32.	IOCs	-	International Oil Companies
33.	VECM	-	Vector Error Correction Mechanism
34.	$	-	United State Dollar (USD)
35.	GHGs	-	Greenhouse Gases

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

An equal and balanced approach to development is known as sustainable development, and it assumes that the interests of various groups of people throughout generations are balanced (Ogboru and Anga, 2015). The importance of environmental management to sustainable development has been acknowledged and embraced on a global scale. This apparent agreement is founded on the knowledge that management is merely a tool and a process for attempting to create a fair balance between environment and development on a sustainable basis. The environment is seen to be at the core of development (Omole and Alakinde, 2013). Every developed and developing nation produces waste. In Nigeria, waste generation and disposal have increased significantly over the past ten years, with the majority of this waste coming from homes, businesses, and industry (Otti, 2016). Waste management is a national and international challenge as both liquid and solid waste are growing, particularly in cities and metropolitan regions. The ability and desire of all essential players (public and commercial sectors) in the waste management value chain to successfully handle the rising volume of garbage poses a significant challenge for maintaining a clean environment.

Living conditions, aesthetics, health, and standards are all impacted by an unclean environment. As a result, poorly dumped waste produces air, water, and land pollution as well as environmental risks (Thaddeus and Onyanta, 2013). When waste is managed effectively, the economy (revenues) grows and the environment is improved. But managing a lot of waste without changing people's habits and lives is difficult (Oyedepo, 2012). Society produces waste, and it can be difficult to manage it responsibly. Prior to the larger pieces ending up in landfills or dumpsites, waste can either be minimized or recycled. This landfill technique is not sustainable since, waste should be considered as resource for new products. For example, generating energy from trash is capable of handling the difficulties of treatment of non-reusable or non-recyclable waste and energy production mix that fulfills customer’s needs (Akhator, et al., 2016). Taking into account both socioeconomic and environmental objectives and/or limits, different methods are used in different countries to manage trash and turn it into energy.

To solve the issues in both the waste management and energy sectors, appropriate waste-to-energy (WTE) solutions must adhere to sustainability principles with an influence on energy security, equity, and environmental friendliness. As the demand for fossil fuels exceeds the availability of environmentally and economically sustainable energy sources, it is urgent to secure a sustainable energy supply. One of the biggest reasons of poverty is a lack of access to electricity. Additionally, if we are to have the best chance of preventing catastrophic climate change, the world needs to begin significantly lowering carbon-dioxide emissions through clean renewable energy within the next few years (WEC, 2016). The management of waste falls under the purview of state and local environmental agencies. The handling, use, and disposal of created solid waste is the responsibility of the agencies. Material recovery from waste, or MSWM, is the abbreviation for the waste- disposal, collection, treatment, and recycling in urban contexts. The objectives of MSWM are to improve the quality of urban life, create jobs and income, safeguard the environment, and aid in the economy's productivity and efficiency.

Municipal Solid Waste (MSW) is described as refuse from residences, non-hazardous solid waste from businesses, institutions, and hospitals, as well as bazaar excess, patch excess, and boulevard sweepings. Regarding their waste management practices, different countries have different classifications and definitions of MSW. MSW comes from a variety of places, including homes, businesses, offices, and governmental and private Institutions. Through the local waste management system, these are gathered and disposed of. Dis-aggregation is hampered by the inconsistent waste definition, classification, and data collecting between nations. When employing waste as a source for producing energy, it is essential to be aware of its composition. Waste-to-energy facilities frequently consume industrial, commercial, and residential MSW (WtE).

The classification and definition of MSW varies depending on the waste management methods used in each country. Households, commercial enterprises, offices, and public and private institutions are the sources of MSW. These are gathered and discarded using the neighborhood waste management system. Separation is hampered by national differences in waste definition, classification, and data collecting. When employing waste as a resource for energy generation, it is crucial to be aware of its composition. Waste-to-energy facilities frequently consume MSW from commercial, industrial, and residential sources. Depending on their composition, calorific values, and societal needs for waste management, other waste sources, such as those from construction, food, forestry, hazardous, agricultural, etc., can be used for waste-to-energy. Plastics, paper, glass, textiles, and metal are the main components of MSW (Eurostat, 2012). Some stylized facts about the Nigerian economy as it relates to the research topic are presented graphically as background:

Table 1.1. Types and Sources of Waste

SOURCE	TYPE	COMPOSITION
Municipal Solid Waste (MSM)	Residential	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g. bulky items, consumer electronics, white goods, batteries, oil, tires), household hazardous wastes, e-wastes.
MSM	Industrial	Housekeeping wastes, packaging, food wastes, wood, steel, concrete, bricks, ashes, hazardous wastes.
MSM	Commercial & Institutional	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes, e-wastes.
MSM	Construction & Demolition	Wood, steel, concrete, soil, bricks, tiles, glass, plastics, insulation, hazardous waste.
MSM	Municipal Services	Street sweepings, landscape & tree trimmings, sludge, wastes from recreational areas.
Process Waste		Scrap materials, off-specification products, slag, tailing, top soil, waste rock, process water & chemicals.
Medical Waste Medical Waste		Infectious wastes (bandages, gloves, culture, swabs, blood & body fluids), hazardous wastes (sharps, instruments, chemicals), radioactive wastes, pharmaceutical wastes.
Agricultural Waste		Spoiled food waste, rice husks, cotton stalks, coconut shells, pesticides, animal excreta, soiled water, silage, effluent, plastics, scrap machinery, veterinary medicines.

Source: Researcher's Compilation

Table 1.2. Current Waste-to-Energy Technologies

TECHNOLOGY	TYPE	CHARACTERISTIC	END PRODUCT
Thermo-chemical	Incineration	Mass burn: Burning the waste at temperature >1000C Co-combustion: With coal, biomass Refuse derived fuel: Using pre-treated fractions of waste with higher and more stable energy contents	Heat Power CHP
"	*Thermal Gasification*	Conventional: Temperature of 750C Plasma arc: Passing waste into a kin at 4000 – 7000C	Hydrogen, Methane, Syngas
"	Pyrolysis	Temperature of 300 – 800C, at higher pressures and in absence of oxygen	Char; Gases; Aerosols; Syngas
Bio-chemical	Fermentation	Dark Fermentation: Organic waste is treated with bacteria in the absence of light sources Photo-Fermentation: Organic waste is treated with bacteria in presence of light	Ethanol Hydrogen Bio-diesel
"	Anaerobic Digestion	Conversion process carried out by micro-organisms in the presence of light	Methane
"	Landfill with Gas Capture	Extraction from existing landfill sites, by the natural decomposition of waste	Methane
"	Microbial Fuel Cell	Catalytic reaction of natural micro-organisms and bacteria to convert the chemical energy content of organic matter	Power
Chemical	Esterification	Reaction of an acid & alcohol to create ester	Ethanol, Bio-diesel

Source: Researcher's Compilation

1.2 Statement of the Problem

The implications for health, the environment, and socioeconomic sustainability make waste management a critical issue (Dizaji, Badri and Shafaei, 2016). The fact that a significant portion of waste is dumped in open dumps or landfills is evidence of the environmental issues that waste management poses globally, particularly in developing countries (Aderonke, Pius and Toyin, 2011). In some countries throughout the biosphere, solid waste poses a serious threat to humanity's ability to use the environment to support their way of life. Due to the importance of solid waste to the fitness and hygiene of municipal civilizations dating back to the nineteenth century, disposal, collection, and management of this waste are global challenges. Even in the twenty-first century, waste management experts and the general public have learned that improper waste management can seriously harm the environment, whereas recycling promotes environmental sustainability. Environmental engineers and the general public have also confirmed that improper waste management leads to significant environmental degradation, whereas recycling promotes environmental sustainability (Otti, 2016).

Due to its over reliance on traditional energy, Nigeria is today confronted with the difficulty of waste management together with declining oil revenues. Energy generation is said to be a global necessity, and nations that have improved power production and distribution are now contending with rising energy demand, leading some nations to rationalize their nation's energy supply (Hurtadoa and Calvo, 2009). Nigeria appears to have had an energy shortage for a while, but various governments have failed to address the problem head-on. The global energy market has gotten worse recently, as indicated by the price of crude oil, therefore finding money to meet this requirement may be a mirage. Ineffective waste management puts the environment and the general people at risk. In Nigeria, it is customary to dump mixed waste that has been gathered from various residential, commercial, or industrial sources in open dumps or landfills. The nation still does not conduct waste separation at the source (Adekunle *et al*, 2011).

The workout of indiscriminately discarding municipal solid wastes, according to Omole and Alakinde (2013), has a price in terms of costs associated with gathering, transit, and removal as well as the damage of worthwhile raw resources (compostable bags, reusables, and recoverable), the adverse environmental effects caused by air, water, and soil pollution, and related safety hazards that inevitably affect the financial sustainability. There is no doubt that this might result in significant environmental issues. Asuquo et al. (2012) found that urban residents in Calabar, Cross River, Nigeria, dump their waste in trash sacks (64%), their courtyards (17%), trenches, pits, uncluttered places, and highway flanks.

In practically all Nigerian urban centers, the tactics are common and widely used, according to their observations, especially now that state governments appear to be overburdened by the growing piles of waste dumps. Without doubt, this exposes them to unnecessary health risks. In the majority of our city, we routinely witness residents personally removing their rubbish to locations (un-) designated as dumpsites, including waterworks next to CAS in Abakaliki. Little amount of them, depending on the circumstance, utilize a car, bicycle, or wheelbarrow (Sule, 2001). Sometimes people will abandon their trash on the highways at night because it is less risky and they won't be seen. Any activities taken to regulate waste- production, transportation, and discharge safely are referred to as "waste disposal" (Atta, 2013).

1.3 Research Questions

The following research questions will be answered by this research work:

1. What are the real sources of waste for energy recovery, the challenges and prospects of waste management practices in southwestern Nigeria?
2. What are the cost and benefit of waste-to-energy recovery generation (ReGen) in Nigeria?
3. What are the impacts of waste-to-energy project on environmental quality, sustainable development and their causality in Nigeria?

1.4 Aim and Objectives of the Study

Based on the above issues raised, the broad objective of this research is to study the techno - economic and environmental assessment of waste-to-energy development in Nigeria. Specific or main objectives are (to);

1. examine the spatial variation, challenges and prospects of waste management practices in southwestern Nigeria

2. conduct cost–benefit analysis of waste-to-energy recovery generation (ReGen) in Nigeria
3. investigate the relationship among waste-to-energy, environmental quality and sustainable development in Nigeria

1.5 Justification for the Study

Humans produce significantly more waste than other living things, and the majority of it is improperly kept, which leads to issues with socioeconomic stability, health, and safety. Therefore, waste management is essential to preserving both the ecosystems of the world and the standard of living of its inhabitants. Waste is quickly becoming a global problem due to the rapid rise in population, urbanization, and industrialization, as well as resource shortages around the world (Narayana. 2009, Hazzra, and Goel 2009). Municipal solid waste management (MSWM) is a bottleneck for developing nations with ineffective operations, little to no planned recycling efforts, insufficient coverage, and few trash processing services (Mbande and Bright 1998; Jun, Yongsheng, and Henry, 2006; Gavrilescu and Abdelnaser 2008).

Different sorts of solid waste exist, including plastics, paper, metals, textiles, glass, wood, bone, food scraps, vegetative matter, etc. These are the main reasons why the environment is polluted. Studies showed that an Israeli city named Ramat Hovar had struggled for years with the issue of organic waste in thousands tons. Similar to this, until the 1970s, the United States' Federal Agencies had no power to control the overtly unsafe disposal of hazardous solid waste at landfills, dumpsites, lagoons, and other bodies of water. If environmental sustainability - a crucial factor in the design of waste management systems is to be maintained, managing solid waste has evolved into a difficult, multifaceted issue that calls a consideration of the social, economic, and technical aspects (Manfredi and Christensen 2009).

Although they have an impact on the environment and ecology, development projects are required to raise the standard of living for a nation's citizens. According to the idea of "sustainable development," these must be carried out sustainably. Economic development, social development, and environmental conservation are the three major tenets of sustainable development. The loss of environmental quality is caused by a number of additional reasons, including the production of trash in both the home and industry (Wolde, 2015). Meeting people's needs and their aspirations for a better life while preserving future generations' capacity to do the same is what is meant by sustainable development. This sustainable development idea has drawn the attention of governments from many nations, international environmental organisations, and researchers for a while now. This is closely related to the acceleration of pollution and environmental deterioration.

Inadequate infrastructure (plants and equipment), lack of funds, lax government control, a poor work ethic, corruption, and bad waste disposal habits are some of the obstacles to effective waste management for sustainable development in Nigeria (Phimphanthavong, 2013). The environmental and socioeconomic issues associated with waste and energy generation are being faced by essentially all branches of the Nigerian government (local, state, and federal). A typical Nigerian generates tons of solid waste each year in their homes, workplaces, and institutions, but one in two of them lack access to dependable electricity or lack energy security. Due to the rapidly increasing waste creation and energy consumption caused by urbanisation and population increase, many city authorities are facing management issues that have never been seen before. The fact that so many different parties stand to gain from this study's conclusions makes it pertinent. By first highlighting the spatial heterogeneity, difficulties, and future potential of waste management techniques in Nigeria.

This study will significantly contribute by identifying the cost-benefit analysis of waste-to-energy recovery generation (ReGen) in Nigeria, as well as by revealing the true connection between waste-to-energy, environmental quality, and sustainable development in Nigeria. This study will make a major and empirical contribution to the environmental Kuznets curve (EKC) theory inside the Nigerian economy. Additionally, knowing where a country sits along the EKC can aid policymakers in developing effective environmental quality control measures (e.g. climate change adaptation and other environmentally related policies). The government and investors will benefit from knowing the cost-benefit analysis of waste-to-energy recovery generation (ReGen) in Nigeria when making decisions and establishing similar localized projects in Nigeria.

Additionally, the study will assist other researchers in the field in selecting appropriate sources and research detours.

1.6. Scope of the Study

This research appraised the techno – economic and environmental assessment of waste-to-energy development in southwestern Nigeria. It respondents from all relevant stakeholders living and working in or around the major dumpsites or landfills in the southwestern Nigeria States. Specialists' meetings and consultations were organized for crucial administrators within the sector to provoke data relevant to stated objectives of the study. Due to the presence of sizeable population, organized waste managers and major dumpsites or landfills in southwest Nigeria, adequate number of relevant stakeholders were available as respondents, for the study. The choice of Southwest Nigeria will not reduce the validity of the result since it remains a decent representation of the country concerning waste managing. This study also attempts to examine and establish the nexus between: waste-to-energy, environmental quality and sustainable development in Nigeria from the period of 1981-2017. This is selected based on the availability of data. The Central Bank of Nigeria's Statistical Bulletin, which is released yearly, served as the study's main data source. The World Development Indicators, annual report and statements of accounts of the Central Bank of Nigeria (CBN), and the National Bureau of Statistics are other sources of data.

1.7. Plan of Study

The study is structured as follows and is broken up into five chapters:

The research's main theme is introduced in the first chapter, which also acts as the introduction. It contains the study's backdrop, problem statement, objectives, as well as its importance, scope, and plan. The literature reviews are in chapter two. Theoretical, methodological, and empirical reviews are included. The study's methodology is covered in chapter three. The empirical analysis is presented in chapter four, and the study's summary, conclusion, and policy recommendations are presented in chapter five.

CHAPTER TWO

LITERATURE REVIEW

Chapter two begins with conceptual review defining key terminologies. Literature were reviewed for some theories and empirical findings on waste -to-energy development and its relationship with environmental quality and sustainable development globally. Proceeding to the review of theories of the structural change models and after which the empiric of previous studies on the subject matter are reviewed. A table was used as summary of the theoretical and empirical review.

2.1 Conceptual Review

The purpose of this section is to enhance understanding of words and phrases in the content of study. For purposes of this research, the following are elucidated:

2.1.1 Energy Security

The ability of the power systems to tolerate disturbances, such as incidents that result in anomalous system conditions and component outages with a minimum amount of tolerable service disruption, is known as energy security. In general, uninterrupted electricity supply is referred to as electrical security. The following factors can be used to categorize potential risks to electrical security: impact locations, time duration, internal or external origin, and intrinsic type. Four key aspects of electricity security can be determined from the dangers described above. The fuel source dimension, market and regulatory dimension, infrastructure dimension, and geopolitical dimension are these dimensions. These four dimensions can be safely envisioned as the actual or virtual channels that the product must pass through in order to reach the end users. When the System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) of Nigeria, the continent's most populous country, are examined, the situation with regard to energy security is rather depressing. The SAIDI statistic was around 1,000 hours per year, compared to the SAIFI figure of not less than 600 interruptions annually. When compared to internationally acceptable criteria of 90–180 minutes for a single interruption and 1-2 frequency of interruptions each year, Nigeria's SAIDI/SAIFI Dichotomy was exceedingly high and utterly inappropriate.

2.1.2 Environment

Environment simply refers to everything that has an impact on an organism or life externally. Anything that has the potential to affect life, be it people, events, circumstances, things, or biotic (living) or abiotic (non-living) variables, Oyeniyi (2011). An ecosystem, a community, or an environment is created by the interplay of biotic and abiotic forces (factors) with living things, people, and society. The success of a given person, plant, or animal species in its habitat depends on even minute changes in any one aspect in an ecosystem or community.

2.1.3 Environmental Quality

Environmental quality can be defined as the absence of waste, contaminants, or pollution brought on by human activity. The degradation of the environment's quality is largely due to waste pollution. Environmental quality has an impact on the satisfaction of both wants and needs, making economic motion subjective. It can also be thought of as a measurement of how well an environment meets the needs of one or more species as well as any needs or purposes that humans may have. This covers the effects that the natural environment, such as air quality and water purity, may have on one's physical and emotional well-being. Given that it possesses the fundamental characteristics of a public good non-excludability and non-rivalry environmental quality is a consumer public good.

2.1.4 Environmental Security

This section examines security first, followed by environmental security, to help readers comprehend it better. The traditional view of security is that it mostly depends on a state's military or its ability to defend itself militarily. All of the measures are directed at stopping all organized crime and defending a region or population while advancing their shared interests through aggressive competition (Bartone, 1991). In light of the aforementioned, environmental security encompasses the attempt to safeguard both the elements that are alive and non-living inside it. It has to do with making the environment habitable for more creatures.

2.1.5 Waste

Any item that has been discarded by a consumer (including businesses) at any time during the item's lifecycle, whether for free or at a cost, is referred to as waste. This waste can be recycled, repurposed, or disposed of entirely or in part. Olaniyan, Ige, and Akeredolu (2015) define solid waste as any material produced by human or animal activity that is no longer valued, meaning it is no longer useful or desired. These materials are often solid or semi-solid in nature. The materials are either recycled or properly disposed of. Residential waste, such as kitchen waste, commercial waste, municipal waste, construction waste, industrial waste, special waste, such as explosive and radioactive materials, securely waste, such as negotiable paper (odd currency notes), agricultural waste, institutional waste, and hospital waste are all examples of solid waste.

2.1.6 Waste Recycling

Recycling is a technique for managing materials in which waste is separated from usable materials, treated to acceptable standards, and then put back into circulation as useful goods (Greppi, 1994). Recycling allows for the reuse of waste that would otherwise be thrown away. The careless use of resources causes an increase in the amount and variety of waste produced. These pollutants cannot be naturally absorbed by an ecosystem, and the current controls, such as landfill or incineration disposal, have a significant negative environmental impact. Reusing and recovering materials through recycling not only lessens environmental risk but also makes it easier to turn waste into goods with value added. Recycling, according to Akinbode (2002), is the process of turning waste into a product or resource that may be used again. Reusing a good can involve doing it by a different entity (perhaps after refurbishment).

Conversely, the term "disposal" is used in this work to refer to the removal of materials without the intention of continued use. This typically involves burying, burning, or just throwing away. On a few precious materials, recycling efforts have tended to be more casual. Since some States have ongoing or upcoming pilot programs, the formal sector is starting to take an interest in them. The Nigerian waste management system makes extensive use of the informal recycling sector. They act as scavengers or itinerant waste purchasers and seek out valuable things like plastics, paper, glass, metal, used electronic equipment, etc. Their actions significantly reduce the amount of waste that is disposed of in net terms. Despite their significance, this stakeholder is not formally integrated into the system outside of Lagos State.

2.2 Theoretical Review

2.2.1 Endogenous Model (or Endogenous Growth Theory): Early 1980s growth literature started to pay more attention to this theory in response to many problems with the assumptions of neoclassical theory. This has the tendency to nullify the assumption of constant returns to scale and replace it with the assumption of increasing returns to scale, after which endogenous variables will mostly drive growth. Human capital and technology are viewed as endogenous variables to be explained by the model. Since the production variables cannot be compensated from the amount produced, the assumption of increasing returns presented severe hurdles to the new growth models and does not hold in a perfect competitive market environment. However, as noted by Romer (1986), Lucas (1988), and Barro (1990), this issue can be solved by only using rising returns that are external to the firm or the system. Romer (1986) provided a thorough description of increasing returns as a key component needed to achieve endogenous growth, whereas Lucas (1986) placed a direct emphasis on the accumulation of human capital as being endogenous in growth models. If everything else is equal, there tends to be a comparatively higher degree of unemployment in an economy with a high population and low level of technology.

- **Assumptions of Endogenous Model:** A unit of factor input increases more than one unit of factor output, which is known as an increase return to scale. The development of both human capital and technology is at the center of technology and human capital.
- **Strength of Endogenous model:** It emphasizes development, positive externalities, and the knowledge-based economy.
- **Weakness of Endogenous model:** Convergence under some conditions is not explained. It is almost impossible to verify using scientific data. In an environment with perfect competition, it does not hold. Increasing returns do not benefit the company or the system.

2.2.2 Endowment Resources Growth Theory:

The most outspoken proponents of this theory with their books are Adam Smith in Absolute Cost Advantage and David Ricardo in Comparative Cost Advantage, as well as other, less well-known figures. They believed that nations should focus on their comparative advantages while producing, exporting, and importing. According to the comparative advantage argument, manufacturing goods that a nation has an abundance of at a lower total cost makes that nation more advantageous than other nations. If the other nations focus on the commodity over which they have an advantage and take advantage of the trading nation's lower costs (Igbosere, 2013). According to the Heckscher-Ohlin (H-O) doctoring of the comparative advantage theory, nations create and export the commodity(ies) that require the usage of their rich productive resources (Feenstra, 2004). According to this theory, developed nations like the United States and the United Kingdom would export goods that required a lot of capital and import goods that required a lot of labor, while less developed nations with plenty of labor would export labor-intensive goods and import capital-intensive goods (O'Toole, 2007; Igboseare, 2013).

- **Assumptions of Heckscher-Ohlin (H-O):**

There are two goods and two countries involved. Humans and other causes are both present. The two nations have unrestricted trade in products and the same degree of technology.

- **Strength of Heckscher-Ohlin (H-O) theory:**

It divides the world's countries into two groups. The word "capital" is used to describe every production component other than human beings.

- **Weakness of Heckscher-Ohlin (H-O) theory:**

Since the second country is the home country, it is actually impossible to interact with only one of them. A nation may own many endowment resources of equal value.

2.2.3 Environmental Kuznets Curve (EKC)

Theoretically, the Kuznets hypothesis is graphically represented with an inverted U curve known as the Kuznets Curve to explain that in a developing nation, as economic inequalities increase over time and with the attainment of a critical mean income, begins to decrease owning to opportunities, education, and compensation gaps. The Environmental Kuznets Curve results from applying the Kuznet Curve to the environment (EKC). In a similar vein, EKC claims that "at certain income level (low), a raise in the nation's income will translate to a rise in environmental pressure level, and as it develops, economic growth will translates to a rise in environmental quality level" (Beckerman, 1992). The EKC concept employed in this research study was inspired by a 1994 paper by Grossman and Krueger, which claimed that economic expansion causes pollution to rise to a certain point before it starts to fall as the economy expands.

The level of several toxins in the environment and economic development were linked in this article. Inverted U-shaped association between income and various pollutants was used, taking into account the theoretical underpinnings and empirical support of EKC research. The EKC, an inverted U-shaped role of per capita income, is shown in Figure 2.1 below. Environmental quality and per capita income have been proven to be associated by research publications. A few studies conducted in the 1990s found that water and air pollution indices increase before falling when per capita income increases, and they have subsequently expanded exponentially (Grossman & Krueger, 1995; Shafik, 1994; Selden & Song, 1994; Panayotou, 1993).

The acronym “EKC” was named after Simon K. (Kuznets, 1955), the pioneer of the study of the relationship between environmental quality and income growth. The abbreviation "EKC" stands for the inverted-U shaped relationship it represents. In an article, Nobel laureate Simon Kuznets showed how the link between income per capita and income inequality takes the form of an inverted-U. (1955). The progression towards steadily increasing income per capita, which is initially correlated with an increase in the rate of environmental quality but then, after a turning point, the rate of environmental quality decreases, is thought to be captured by the inverted-U shaped environmental Kuznets curve (Webber & Allen, 2011). The Environmental Kuznets Curve (EKC) hypothesis is based on the premise that attaining high levels of economic growth will result in improved environmental quality. Although the environment will initially deteriorate during development, there will eventually come a turning point where the quality of the environment will improve. Developed countries are wealthy enough to buy energy-efficient products after reaching a turning point in their economic development, while less developed and emerging countries i.e. consuming developing nations import pollution-intensive goods from them (Grossman and Krueger, 1995).

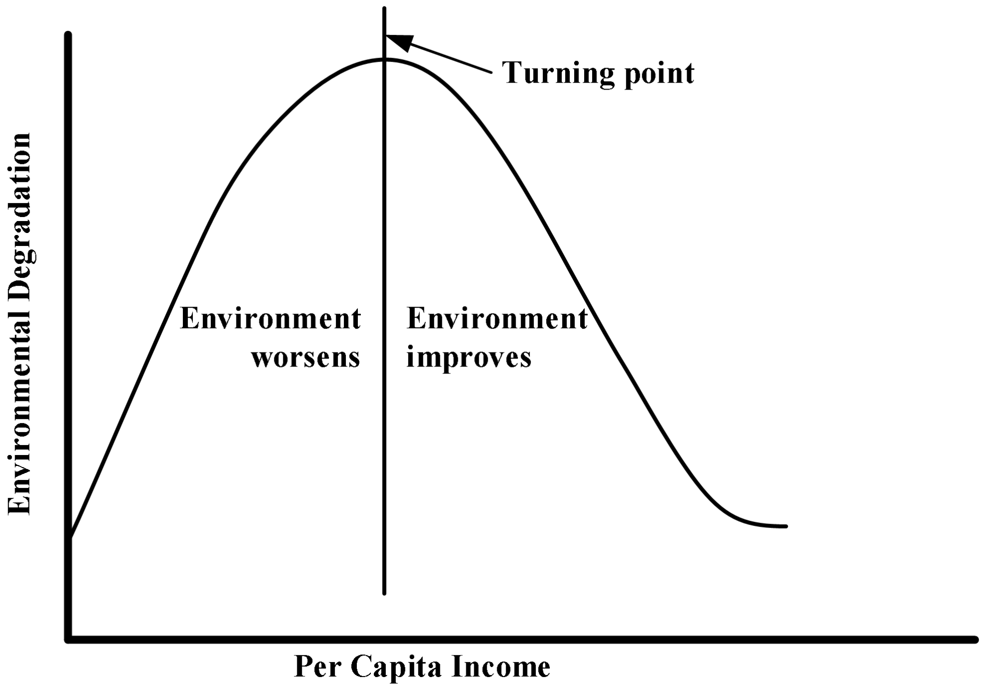


Figure 2.1. Environmental Kuznet curve (Source: Researcher's Compilation)

The three stages of an agrarian economy's production that lead to the fictitious relationship between income growth and the environment are noted by Webber and Allen (2011). According to them, there are three stages of growth that are involved namely;

1. Agriculture and light manufacturing, which have a low degree of pollution, first dominate output.
2. The shift in production toward heavy industry results in a comparatively high amount of pollution.
3. High-tech industry production then predominates, resulting in a comparatively low amount of pollution.

According to the logic of this hypothetical curve, production moves to heavy industrial activities in the second stage of economic growth, which produce an increasing level of environmental pollution, leading to an increasing rate of correlation between income growth and environmental quality. However, as income rises and the manufacturing process continues to migrate to high-tech industries, this rate falls. A turning point in the level of environmental quality is reached as the economy advances to the third stage of the industrial process. Any increase in income growth after this turning point will result in a decline in environmental quality. This denotes an inverse relationship between that point and the third stage of economic expansion.

In addition, low-income nations may be able to improve their environmental conditions if they are successful in disassociating resource usage and environmental damage from economic growth (Panayotou, 1997). Changes in structure, technology, policy, or a combination of all three may be used to accomplish this. The systemic transformation that the formerly planned economies are going through involves a temporary decoupling as previously unpriced or incorrectly priced resources are brought into the realm of markets. Only full-cost pricing that includes environmental externalities will lead to sustained decoupling. Developed countries re-couple economic growth and the environment by providing subsidies to the energy, transportation, and other industries that produce harmful pollutants. Due to faster population growth and economic growth brought on by the transition and convergence processes, developing or transitional countries that do not get environmental subsidies must pay more for the expansion of their economies. There are major technological and structural changes associated with the convergence process. The decoupling effect of these improvements could, however, be negated by scale effects unless it is supported by aggressive and conscientious environmental legislation. However, as the demand for such programs is often income elastic, it is most likely to be moderate in low-income nations. As a result, exogenous inducements such as help from wealthier nations may be required to accelerate the decoupling of environment and income growth in low-income countries.

This suggests that the aforementioned factors cause the environmental Kuznets curves of transitional economies to be steeper and skewed than those of advanced nations. However, Müller-Fürstenberger, Wagner, and Muller (2004) demonstrate that while the environmental quality level for both countries may be the same at the turning point, in economic development, it would not be. They predict that the developing countries' turning point environmental quality level will be greater than the advanced country's turning point environmental quality level. Their argument is that, in order to overcome their low levels of output and income before reaching their turning point levels of revenue development, developing nations will import very ecologically harmful technologies.

Results from Panayotou (2003) show that there is a technology gap between developing or emerging markets and transitioning economies. While developed economies are implementing cutting-edge technologies in which emerging market societies are still coming up to the environment-intensive technology of the preceding generation, which allow dissociate industrial expansion from constraints on the ecology and raw resources, that govern the transportation and power industries and are to blame for numerous environmental issues. Again, developed countries can support the gradual shift in consumer preferences in developing countries away from products with high environmental impact and toward those with greater environmental protection by assisting in accelerating transitions to new eco-friendly know-hows like renewable energy and transportation.

Relative costs of different energy sources, fuels, and transportation modes, which are determined by markets and governmental regulation, will ultimately have an impact on the adoption of more efficient technology. But there have been arguments for and against the Environmental Kuznets curve (EKC) theory. While some argue in favor of it, others argue against it. The arguments are theoretical and supported by actual facts that could be seen as being in direct opposition to the hypothesis. Therefore, we explore some of the theoretical arguments for and against the Environmental Kuznets Curve theory in the next two subsections (EKC).

Ehrlich and Holdren (1971) suggested an IPAT model to illustrate this strategy as [(Population*Affluence*Technology) = Impact], where technology is defined as the impact or emissions per dollar of income and affluence is defined as income per capita. The notion that poverty reduction is necessary for environmental protection and that development does not always equate to environmental destruction gave rise to the idea of sustainable development in the 1980s (WCED, 1987).

The EKC concept was introduced to sustainable development by Grossman and Krueger's examination of the probable effects of the North American Free Trade Agreement (NAFTA) in 1991. The unfettered trade, according to NAFTA environmentalists, would spur economic expansion and lead to environmental damage in Mexico. However, they claimed in their analysis that a rise in the economy will lead to an improvement rather than a decline in Mexico's environmental quality. An empirical investigation of the correlation between income per capita and ambient pollution levels in a number of cities throughout the world using the GEMS database served as evidence to support the claim. The results demonstrate that when any country acquired almost the level of per capita income attainable in Mexico at that time, pollution concentrations increased.

The 1992 World Development Report by the World Bank, which included contributions by Shafik (1994), brought the EKC to public attention. It had been posited that the idea that increased economic development will unavoidably harm the environment is founded on outdated notions of environmental investments, preferences, and technology and that as income rises, there will be more resources available for investment and a greater demand for environmental quality improvements. Beckerman (1992) went on to say that although environmental quality will be impacted by economic growth in the early phases of the process, growing wealthy is ultimately the best method for nations to have a respectable environment. In his analysis, Shafik claimed that waste generation and carbon emissions did not follow an inverted U-shaped curve.

Later studies, however, dispelled this skepticism about the validity of the EKC hypothesis with respect to pollution output (emissions). Findings by Panayotou (1997) revealed a initial justification for the reality of EKC. Without modifications to the technical and organizational frameworks that support an economy, scale effect, or economic expansion, would result in an increase in the negative effects of pollution and environmental degradation. This result reflects the conventional wisdom that economic advancement and environmental quality are incompatible. The supporters of the EKC proposition argued that high stages of progress would result in operational changes that would create information-intensive industries or services, better technology, more environmental spending, awareness, and regulation enforcement,. EKC is thus explained by the following reasons;

1. The scale of production is the amount of production that is increased while keeping the mix of products produced, the mix of production inputs used, and the level of technology unchanged.
2. Different industries produce pollution of varying intensities, and Copeland and Taylor's composition effect theorizes that as economies evolve, the mix of outputs varies (2004).
3. Changes in input mix refer to the substitution of more ecologically detrimental inputs for less environmentally damaging inputs and vice versa.
4. Technology advancements call for adjustments in both of these areas:

(a.) production efficiency, which measures how much less polluting inputs are used to produce one unit of output, ceteris paribus.

(b.) changes in process-related emissions result in lower pollution emissions per unit of input.

The technique impact is the collective name for the third and fourth variables, according to Copeland and Taylor's (2004) findings. Changes in underlying variables, such as environmental education, awareness, and regulation, which are driven by other fundamental variables, may in turn affect proximate variables. Some studies have created theoretical models that describe how choices and technology combine to provide various routes for environmental quality time (Copeland & Taylor, 2004; Kijima, Nishide & Ohyama, 2010; Panayotou, 1997). The two main techniques in this literature are dynamic models and static models. While dynamic models took into account changes in environmental quality or emissions as well as the process of economic growth, static models depicted economic growth as a change in production level (Kijima et al, 2010).

Static models approach pollution as an input for the manufacturing of consumer products, assuming that there is a representative customer who maximizes a utility function that depends on pollution and consumption level. Both static and dynamic models presuppose the absence of unadjusted externalities or the establishment of a price for pollution that is socially efficient. In accordance with the simple premise of additive preferences, Pastern and Figueroa (2012) demonstrate that;
$\frac{dP}{dK} > 0 \textit{ if and only if } \frac{1}{\sigma} > \eta$ and vice versa. where K is capital, P is pollution;

i.e. all other inputs to production apart from pollution, σ is the elasticity of substitution between K and P in production, and η is the absolute value of the elasticity of the marginal utility of consumption. The smaller σ is, the more difficult it is to reduce pollution by substituting other inputs for pollution. The larger η is, the more difficult it is to increase utility with more consumption. Therefore, the likelihood that pollution will increase as the economy grows, the difficulty of replacing pollution with alternative inputs, and the ease of increasing utility through increased consumption are all inversely correlated. This means that EKC is nonexistent if either of these values is constant. According to EKC driven by the elasticity of marginal utility and substitution as the economy expands, Copeland & Taylor (2004) categorised the models.

Different assumptions about how institutions control environmental quality are made in EKC dynamic models. Collective judgment affects the direction taken in terms of income-pollution and societal utility. According to Jones and Manuelli's (2001) model, the younger generation might charge older generations for pollution that occurs as they age. However, Brock and Taylor's (2010) Green Solow model makes no explicit assumptions about consumer preferences or the cost of pollution. Its premise was more based on the stylized facts, according to which a constant percentage of economic output is used to reduce pollution. Building on the 1956 Solow economic development model, this research significantly accounted for more data parameters than the previous one, such as the drop in emissions intensity and the costs of abatement. Their model used the assumption that pollution results from production, but that it may be reduced by devoting a portion of final production to pollution abatement. This suggests that emissions levels will eventually converge in all nations, albeit they may first rise in less developed nations due to rapid economic expansion before falling. Recent empirical evidence demonstrated the model's inadequacy in explaining changes in emissions and the economy.

First, the assumption that the proportion of manufacturing cost reduction is constant was not included in the Green Slow model, and other assumptions were not disclosed. Second, the starting levels of income per capita and the country's subsequent growth rates, which are what propel income convergence in the Solow model, have little to no association (Durlauf, Johnson & Temple, 2005). Additionally, the assumptions made by static models regarding how best to internalize pollution externalities throughout the course of economics are not very believable. As a result, there is a very broad opportunity for future study on theoretical environmental quality and economic growth models.

2.2.4 Environmental Convergence Hypothesis

According to this theory, starting circumstances play a role in explaining long-term results. In this way, the essential idea behind convergence studies is illustrated. Convergence simply refers to the asymptotic similarity or equivalence of two countries' growth rates that are observed to have comparable technologies and preferences but different beginning physical and human capital pools. According to the definition of convergence economics, "Convergence property originates from the diminishing returns to capital in the neoclassical model. Greater rates of return and faster growth are typical in economies with lower relative capital per worker, according to Brock and Taylor (2010, p.142). Similarly, "countries or regions starting from very different levels of output per capita, evolving in stable environments, and having access to the same technology should experience convergence: the dispersion of their output per capita should diminish; poor countries should grow more quickly than rich ones." is a similar description of convergence. Therefore, the economics of convergence is related to whether the growing course for an economy through precise technology and desires displays several stable conditions or multiple invariant measures in a stochastic setting. Li and Chow (2004, p.6). The consequences of environmental deterioration on economic activity should not be limited to the EKC; there is a considerable association between environmental quality and income (Bruvolet al., 1999). Growth is impacted by these health-related issues and others in a variety of ways.

As evidenced by its significant weight in the SDGs, health plays a major part in the monetary policies of numerous emerging nations. The EKC hypothesis is the focus of many worldwide studies in this area, but studies interested on reserve causality are few in number. Degradation of the environment still has a significant impact on human health and other aspects of economic growth. As the effect of environmental quality is reduced, convergence generally tends to increase a little. The idea of economic convergence, first put forth by Solow in 1956 and generalized by Anjum in 2014, has been put to the test and enhanced. Countries or regions would arrive at their corresponding steady states for conditional convergence. The simplest way to comprehend how environmental deterioration affects economic growth is to identify the routes that cause it. These pathways, including labor supply and productivity, are frequently mentioned in literature, either implicitly or explicitly.

In countries with incomes below the EKC threshold, efforts to enhance financial progress will have an outcome in more ecological ruin, which has a negative impact on health and other areas of society. For nations with incomes above the EKC threshold, on the other hand, environmental quality declines as economic growth increases, creating a positive feedback loop. When convergence speed decreases, poor countries suffer. GDP is a factor in pollution since it is connected to development. This demonstrates the connection between individuals, the economy, health, and the environment. There are few empirical analyses of how environmental degradation affects economic performance, and those that do exist tend to focus on microeconomics rather than other factors like frequencies of broadcast.

2.2.5 Pollution Haven Hypothesis and Environmental Dumping Hypothesis Suggest that environmentally destructive industries will relocate to regions with weaker environmental rules. According to the pollution haven theory, polluting companies will relocate to jurisdictions with lax environmental restrictions (pollution havens) from those with stricter regulations. Environmental laws will reduce comparative advantage jurisdictions in those items and increase the charge of critical contributions to things with pollution-concentrated manufacturing. The Heckscher-Ohlin model offers the theoretic underpinnings which show areas or nations exporting inputs made up of locally abundant items. But empirical data refute the notion that businesses will move their manufacturing to a region with weaker regulations. (Becker et al., 2000).

According to the theory of environmental dumping, waste is moved from one nation or region to another, typically to one with less or no rigorous environmental rules. Because it is permitted to ignore the economic laws of the original country, this economic approach is regarded as being inexpensive.

2.2.6 Welfare Economics

The theoretical basis of Cost Benefit Analysis is Welfare Economics which is associated with two theorems. Firstly, is that competitive markets yield Pareto efficient outcomes, and secondly is that social welfare can be maximized at an equilibrium with a suitable level of redistribution. It is hinged on three concepts namely; total surplus, allocative efficiency, and the social welfare function. Its social side is focused on evaluating alternative methods in collective decision-making as logical foundation. Welfare Economics theory facilitate the scrutiny of the performances of both actual and imaginary economic systems, as well as with the critique, design and implementation of alternative economic policies. Thus, its origin can be traced back to antiquity, guiding the collective decisions of multiple individuals for a common course (Suzumura, et.al., 2001; Starr, 2003).

2.3 Empirical Review

Using a panel data model, Dizaji et al. (2016) assessed the connection amid environmental eminence and economic growth in the D8 members Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan, and Turkey between 1975 and 2012. The results demonstrated that economic expansion has a favorable impact on carbon dioxide emissions. However, the square of the GDP per capita has a large detrimental impact on carbon dioxide emissions. According to the study's findings, the EKC hypothesis holds true across the examined countries. Wolde (2015) questioned the existence of EKC in his analysis of the connection between economic expansion and environmental degradation in Ethiopia. Through the application of the Vector Error Correction Model, time series data spanning the years 1969 through 2011 were used to investigate the relationship (VECM).

According to the findings, the EKC hypothesis stands true in Ethiopia, which is similar with findings from other nations that show that environmental degradation increases early on and reduces with rising economic growth later on. The cause was determined to be a rise in the service sector's contribution to economic growth and the application of environmental law to economic activities.

The current economic policy in Ethiopia should be sustained to keep the country on its environmental sustainability course. Jan Steins (2002) conducted study on organizational theories, models, and conventional business economic approaches, polluter-pays principle and appropriate waste management tools. To make the model's societal context more clear, the methodologies were adjusted or applied to waste management. The findings indicated that by modifying conventional cost-revenue approaches, the polluter-pay principle could be implemented in industry. With a focus on the social and technical aspects of residential generation of waste and processing, Aisa et al. (2011) explored how householders participated in MSW management in the major cities of East African Countries.

Ning (2011) researched on the difficulties of municipal solid waste management and sustainable urban development (MSWM). Waste management must be timely and efficient as population and waste production rise in order to support sustainable development without endangering the capacity of future generations to meet their own requirements (WCED, 1987). The influence of waste disposal on other jurisdictions and/or future generations is typically passed on when waste from cities or metropolitan regions is exported to another location for processing and treatment.

The system is not sustainable in this metropolitan situation because more resources are needed than are available for production and more waste is produced than can be processed by the environment. The results demonstrate that, with the right strategic policy design and waste reduction program implementation, waste creation and effects can be decoupled from urban expansion and population. Housing density, building age, and income were also mentioned as issues faced by communities with diverse characteristics.

Phimphanthavong (2013) investigated the link between environmental deterioration and economic growth. Data from 1980 to 2010 were utilized. His research was based on the EKC theory, according to which economic expansion and environmental deterioration follow an inverse U-shaped relationship. The results support the EKC hypothesis that there is an inverse relationship between economic growth and environmental degradation, with economic expansion initially increasing environmental degradation levels but decreasing them as a function of income per capita. Full ASEAN membership, industrial expansion, and commercial openness were some of the causes of the increase in environmental degradation. It suggested improved environmental and natural resource conservation strategies for the present and future realization of Laos' SDGs.

Abdullai and Ramcke's (2009) investigation focused on the connection between economic development, trade, and environmental degradation in both developed and developing nations between 1980 and 2003. The results indicate that EKC is present in most contaminants, but they do so with a number of caveats, suggesting that none of the theories linking global trade to environmental degradation can be entirely supported. The results indicated that trade liberalization would be advantageous for sustainable development in wealthy countries but harmful for underdeveloped nations. According to the study's findings, wealthy developed nations should take the initiative in addressing environmental degradation issues and supporting underdeveloped third-world nations lacking effective environmental laws.

Yang et al. (2007) used time series data between 1981 and 2006 to study the association between economic development and environmental pollution using the Johansen cointegration test and Granger Causality test techniques. The three types of pollution indices taken into account were the amount of industrial waste gas released, the amount of industrial wastewater ejected, and the products of industrial solid waste material. Long-term data on the pollution indices show a negative co-integrating connection with GDP per capita, demonstrating that economic growth is not always correlated with environmental deterioration. It was incorrect that GDP per capita in granger generated (caused) pollution emissions of industrial wastewater and industrial waste gas, with the exception of industrial solid waste discharge. The study proposed more extensive environmental investments, tighter environmental policies and regulations, and coordinated research on economic growth and environmental protection that takes other regions into account.

Ogboru and Anga (2015) researched into how Nigeria's sustainable economic development can be harmed by environmental degradation. The results demonstrated that environmental pollution causes diseases like cancer, tuberculosis (TB), viral illness, and others that are harmful to long-term economic growth. They underlined the effects of environmental degradation as being erosion, decreased agricultural output, and floods. As steps toward promoting individual well-being and sustainable economic growth, they suggested enabling policies, economic tools, and incentives.

Ejuvbekpokpo (2014) assessed the effect of carbon emissions on Nigeria's economic growth using secondary data for the 1980–2010 time period from CBN and IEA. Ordinary Least Square (OLS) approaches were used to evaluate variables such as GDP, solid fuels, liquid fuels, gas fuels, and emissions from fossil fuels. The results demonstrated that carbon emissions have a detrimental effect on the nation's economic expansion. He suggested that the government, IOCs, and other players from the public and private sectors work together to enact measures to reduce GHG emissions and nurture an environment free of carbon emissions in Nigeria and other oil-producing nations.

Akpan and Chuku (2011) assessed the EKC's policy relevance in Nigeria using time series data from 1960 to 2008 and ARDL. By utilizing carbon dioxide emissions per capita as a proxy for environmental degradation, they expanded the EKC model to incorporate trade openness, shares of the service, manufacturing, and agricultural sectors in Nigeria's GDP. The findings did not prove the existence of the EKC hypothesis, but they did show that the situation in Nigeria was represented by an inverse N-shaped relationship with a turning point of $77.27 (USD) and a value below the studied data set. This portrayed EKC as a deceptive policy manual for reducing environmental threats in the nation. For sustainability, they advised looking beyond EKC and implementing environmental protection laws in Nigeria regardless of income level.

Using VECM and co-integration methodologies, Akomolafe, Danladi, and Oseni (2015) assessed the association among economic growth, trade openness, and environmental pollution in Nigeria. Urbanisation and ruralisation were presented as measures for the growth of the urban and rural sectors, and their effects on pollution in Nigeria were examined. The results demonstrated the existence of EKC in Nigeria, a positive association between environmental pollution and ruralisation (both short- and long-term), as well as a short-term positive relationship but a long-term negative relationship between environmental pollution and urbanisation. To control environmental contamination in Nigeria, they suggested that environmental regulations be passed and implemented.

Rapid urbanisation, industrial expansion, resource scarcity, and a lack of technical and managerial skills were recognised by Omran (2011) as the main issues facing the management of solid waste in the Libyan city of Bani Walid. According to him, if proper waste management systems that cover trash processing, treatment, and disposal are not effectively developed, a rise in waste might result in environmental deterioration as well as health problems. For efficient management in Bani Walid city, he suggested more public knowledge and social acceptance of created MSWM methods.

Adewole (2009) conducted research on the application of refuse management for sustainable development in Lagos State. The study explored the root causes of waste issues and how their management affects people's quality of life. As a means of minimising pollution, he suggested recycling waste. The study explored the root causes of waste issues and how their management affects people's quality of life. As a means of minimising pollution, he suggested recycling waste.

Abila and Kantola (2013) made an effort to compile the issues with MSWM in Nigeria. A conceptual approach to knowledge management for handling waste issues in Nigerian cities was suggested by the study. This method and plan will encourage a shift in attitudes among people, households, providers of waste management services, and customers, as well as the successful implementation of governmental legislation for better waste management. According to the study's findings, impediments to successful waste management in Nigeria include poor staff morale, limited global alliances, a lack of centralized containers for waste, poor product manufacturer involvement or interventions, packaging, and cultural beliefs. The study suggested MSWM solutions that were focused on both people and technology.

Applying the theory and flowchart model to waste management that included waste collection, disposal to approved dumpsites, and quick decomposition using worms, Muhammed (2009) evaluated sustainable development in Malaysia (Vermicompost within a month). Vermicompost is an environmentally beneficial manure that helps to maintain a clean, fresh, and healthy environment around the nation.

In their 2008 study on waste management in a state in Southeast Nigeria, Modebe and Onyeonoro discovered how households in the Anambra State metropolis of Awka handle their waste. The study used cross-sectional data and a descriptive research design. Using a multi-stage sample method and questionnaires, 200 houses were chosen. The most frequently produced waste in Awka were organic waste and nylon bags. 85% of those surveyed did not segregate their rubbish before disposal and instead kept it in locked containers. 70% of people used government waste managers to dispose of their waste, 27% discarded waste carelessly, and the remaining 35% used mobile cart pushers. Recycling waste is practiced by 18% of the population. More than 50% of respondents urged that the government take more action to enhance waste management and expressed unhappiness with the extent of its involvement. For Awka's waste management issues, it was advised that the government, commercial sector, and community participation should all be increased (Modebe, et.al., 2008).

Englande and Guang (2003) looked into how biotechnology could be used to control waste for sustainable development. A summary of strategies for managing industrial waste that take into account the sustainability of resources and the biodegradation of industrial pollutants was given. The discussion included biotechnology approaches that support the Sustainable Development Goals (SDGs), regulatory considerations or trends, toxicological assessment evaluations for resource reuse, treatment trends, novel strategies, and residual management. The report suggested biotechnology as a crucial element required to accomplish the SDGs.

Otti (2016) research identified various forms of integrated solid waste management for Anambra State (ANSEPA) that can be used to plan long-term industrial projects while reducing costs and optimizing benefits. Maximum environmental benefit was identified as the biggest value and minimal maintenance cost was identified as the smallest value of the objective function. The optimization system was accepted as both a practical and ideal solution. The created optimization model captures every component of waste management with its planning issue, has cutting-edge characteristics, and does away with conventional modeling constraints. The study came to the conclusion that finances are a significant barrier to a model's efficacy or efficiency and that system engineering tools can help decision-makers manage challenging planning scenarios. It addresses numerous limitations that are typically seen in frequently used optimization modeling for waste management and incorporates a number of novel features. Additionally, a lack of funds hinders the usefulness and efficiency of the models. Similar to the Nigeria factor, financial resources are frequently hard to come by, which means that model goals may be postponed due to delays in garbage collection, disposal, and planning management, among other potential disruptions. System engineering solutions can help municipality and community decision-makers manage the difficult planning environment as MSWM planning becomes more complex.

Omole and Alakinde (2013) both cited the costs of collection, transportation, and disposal as well as the loss of resources (raw materials used for recycling, reuse, and repair), environmental degradation (pollution of the air, water, and soil), health risks, and detrimental effects on the sustainability of the economy.In cities as Abakaliki, where the administrator is still struggling to deliver rudimentary communal services rather than environmental sanitation, mountains of waste may start to become the norm.

Asuquo et al. (2012) researched the waste disposal practices in Nigeria's eastern city of Calabar. 64% of people dispose of their refuse in cans, with the remaining 26% ending up in gutters, pits, fields, and road sides. Most Nigerian towns use these approaches as standard operating procedure, which has left different state governments overburdened by the rising waste and health dangers exposure in their urban centers. Few urban inhabitants employ a truck, bike, or wheelbarrow, motor bike or truck, instead choosing to manually transport their waste to (un-) designated dumpsites or lanfills (Sule, 2001). People carelessly dispose of their waste under the cover of darkness.

Waste disposal refers to actions made to regulate the production, transportation, and sanitary discharge of waste (Isaac and Olanike, 2007, Ogwueleka, 2009 and Atta, 2013). According to this concept, proper waste disposal is primarily done to lessen its impact on human health, the environment, or aesthetics. The use of a sustainable waste disposal system offers a thorough, multidisciplinary framework for solving waste management issues. As a result, the high efficiency upgrading of contemporary waste disposal system services will aid in boosting the environmental quality of metropolitan areas. Appendix A provides an overview of the literature review.

CHAPTER THREE
RESEARCH METHODOLOGY

This chapter describes the research methods and approach selected to realise the study's aim and objectives. The choice of the methods are based on the nature of the study research questions and objectives. This study borders on the techno - economic and environmental assessment of waste-to-energy development in Nigeria.

3.1 Survey Area

Nigeria, the most populous black country in the world and the most populated nation in Africa (more than 210 million people), is a developing country with a population of over 200 million and a land mass of 923,768 km2. With a population density of 140 persons per square km, 48.3% of its residents live in urban areas, while 52.7% do so in rural ones. A little over half the population lives in poverty, with a GDP per person of roughly $2,000 per year. Nigeria is a country in West Africa that borders the Gulf of Guinea. Nigeria shares land borders with Chad and Cameroon in the east, Benin Republic in the west, and Niger in the north. It has a coastline that is about 853 kilometres long. Nigeria's landscape is varied, encompassing the Obudu Hills located at southeast, beaches located at south, the rainforest, Lagos estuary, Savannah located at the middle-belt and southwest, and the Sahel to the expanding Sahara in far north. The Benue and the Niger are Nigeria's two main rivers. These two rivers merge near Lokoja and drain into the Niger Delta, the world largest river delta, giving Nigeria its "Y" shape. Southwest has the most developed commercial infrastructure from the 6 geopolitical areas or zones. It is also the country's cocoa belt and has significant agricultural and (renewable) energy potential.

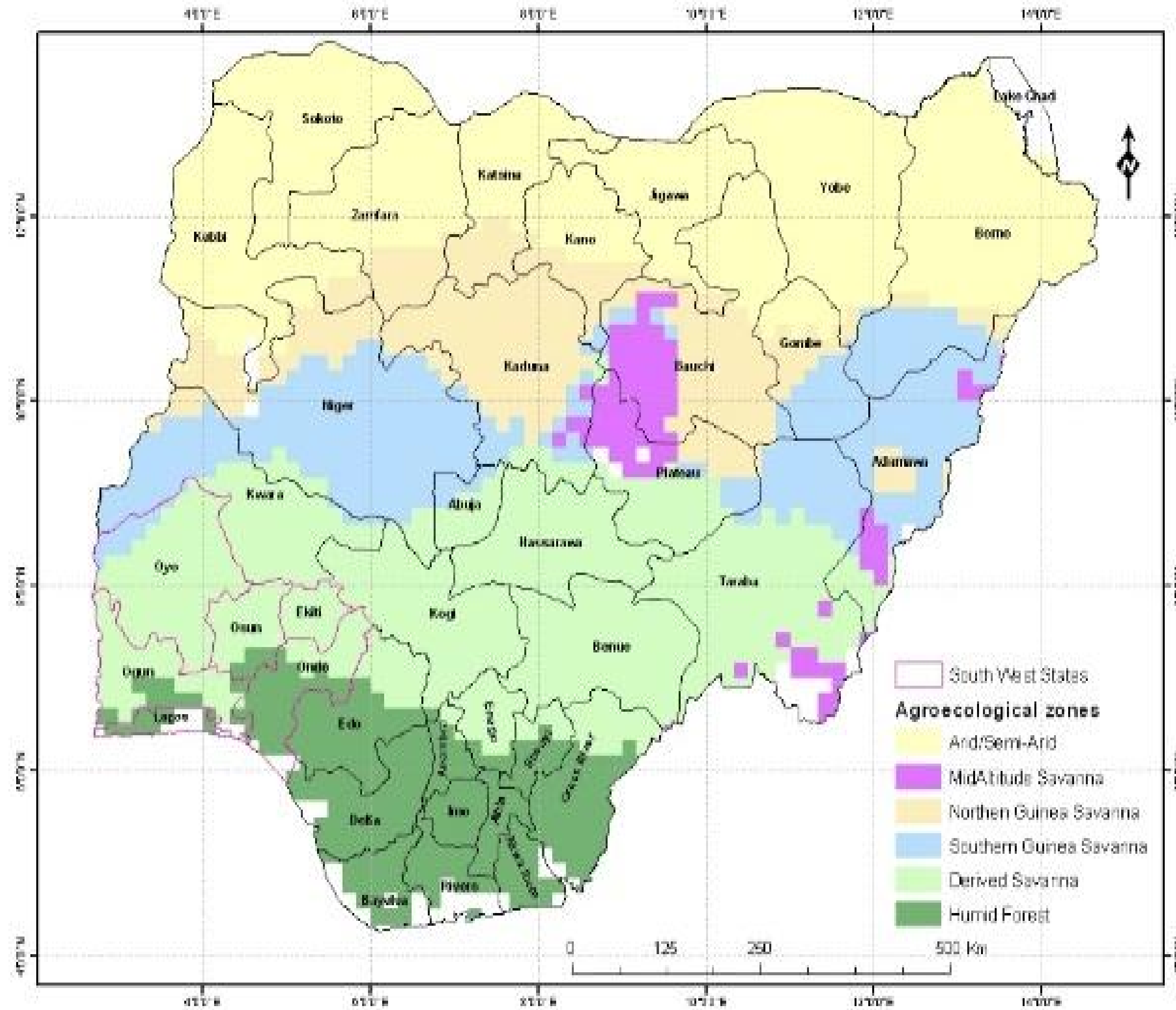


Figure 3.1. Nigeria Map (Source: Researcher's Compilation)

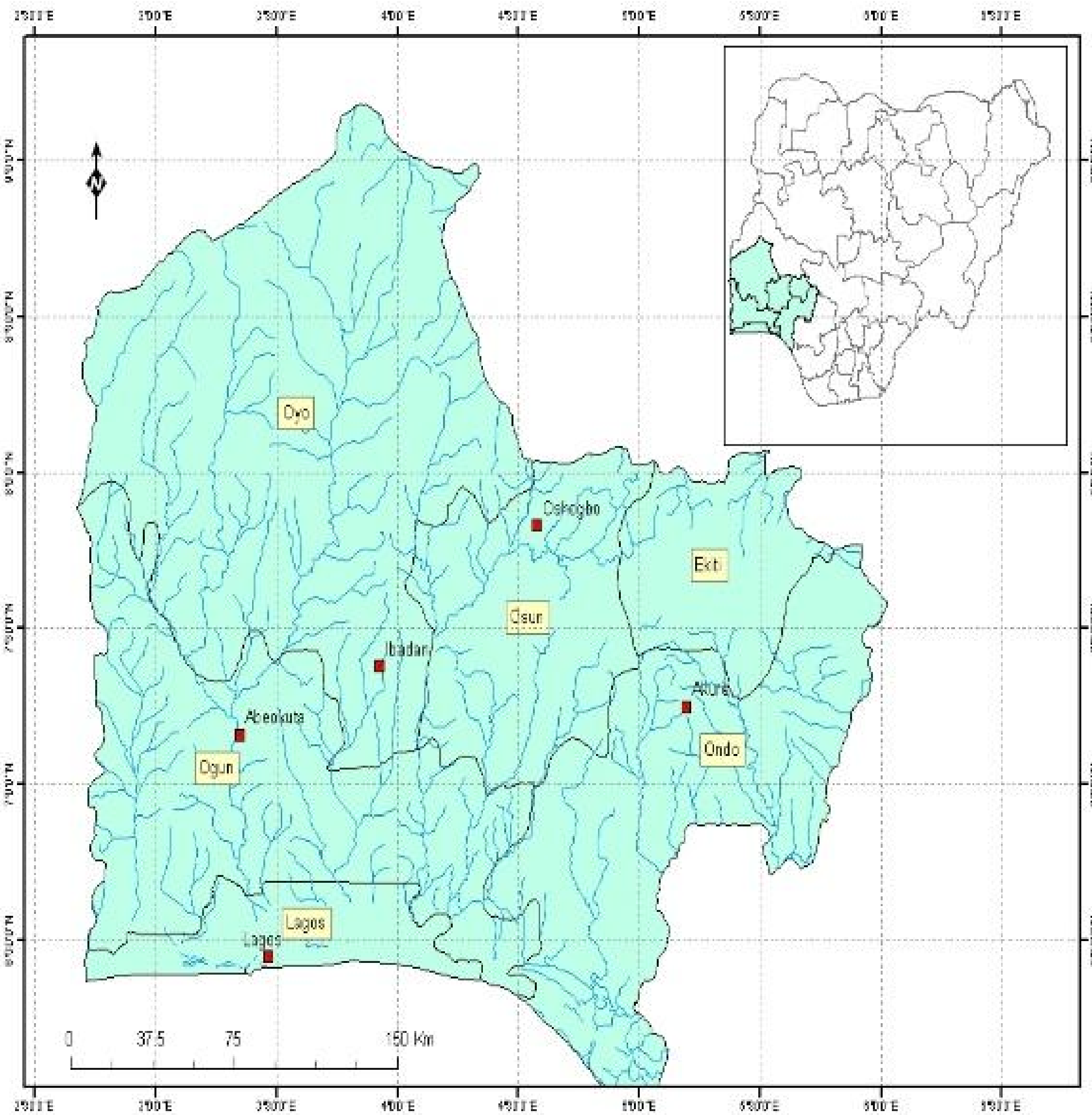


Figure 3.2. Southwest Nigeria Map (Source: Researcher's Compilation)

3.2 Conceptual / Theoretical Framework

The methodologies used for this investigation are essential to the validity and dependability of the findings. This methodology section so focuses on the selection of research procedures employed with the aim of realizing the research's aims. Also described were the tools that were utilized to measure the numerous constructs relevant to this study project. Subsections on model definition, research design, sampling approach, estimating technique, and sources and data measurement provide descriptions of these methodologies. This research's theoretical framework is based on Simon Kuznet's Environmental Kuznets Theorem from 1950 in order to examine the techno-economic and environmental assessment waste-to-energy development and evaluate the relationship between waste-to-energy, environmental quality, and sustainable development in Nigeria. According to the Environmental Kuznets Curve (EKC) hypothesis, environmental harm is directly tied to poverty, therefore improving the economic standing of the poorest people will benefit the environment. This implies that an economy's rising income and consumption levels would probably cause a net worsening of the environment. According to a widely held theory known as EKC, environmental pollution and degradation would first rise and then reduce as income per capita increased. This EKC framework supports the fact that as income per capita rises, environmental degradation and pollution initially rise and then decline. Inequality may worsen in the initial stages of economic growth as a result of structural changes, in accordance with the Lewisian model, growth may be concentrated in areas with few jobs but high earnings and productivity, as is typical of the modern industrial sector. The EKC hypothesis contrasts the idea that as money rises, society will have the ability and the will to pay for environmental protection.

There is evidence to suggest that other environmental deterioration decreases as income rises, but the EKC inverted-U relationship is only relevant for local pollutants including sulphur dioxide, nitrogen oxide, and air particulates. Even if EKC exists in the long run, some environmental problems caused by GHGs, such as biodiversity loss, may be irreversible. Kuznets argued that as a nation transitions from a traditional to a modern economy, the EKC can be produced through steady processed contemporary sector expansion growth. Todaro & Smith (2011) noted that although Kuznets did not explain how his inverted-U theory came to be, it is in fact consistent with a constant process of economic growth. Because the net change in inequality resulting from traditional and modern sector enrichment is ambiguously in opposite directions, the validity of EKC has become an empirical challenge. The advantages of this methodological argument have, however, been overlooked by certain development economists, who claim that the EKC of early increase and later reduction inequality is inevitable. Countries like Taiwan, South Korea, Costa Rica, and Sri Lanka have shown that, depending on the development process, increasing income levels might result in reducing inequality rather than rising inequality. What connection exists between Nigeria's growing socioeconomic disparities and its economic and environmental problems? This study adds to the theoretical discussion by evaluating the relationship among waste-to-energy, environmental quality, and sustainable development in Nigeria.

3.3 Survey Methods

In this investigation, samples were picked at random. Sampled respondents were given structured questionnaires to complete. With the random sampling method, each subject or component is equally likely to be chosen. This method prevents biased results and provides psychometric conditions for the variables used. Residents, employees, and other stakeholders in the vicinity of major dumpsites or landfill areas in southwestern Nigeria States are the subject of this study's first objective. It was conducted in the six states of Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti, which are all in Nigeria's southwest (SW) geographical zone. For the study's first objective, a total of 210 households in Southwestern Nigeria and 40 households in Ghana (Accra, Legon, and Pantang) were sampled as part of my host University of Ghana Business School (UGBS) requirement for my 11 months European Union Mobility HEED-Africa Fellowship during this doctoral (PhD) research. Spreadsheets were used to enter the study's data. The Statistical Package for the Social Sciences (SPSS) version was used for data analysis.

In the uni-variate analysis, descriptive statistics including mean, standard deviation, frequency counts, percentages, bar charts, and graphs were combined with inferential statistics. The respondents were chosen using a stratified random sample technique for better coverage and less expense. The 210 houses that made up the sample size which included inhabitants, employees, and other waste management stakeholders, were chosen using a stratified random sampling technique in southwest Nigeria and 40 households in Ghana. The amount of assurance that the features of the figures obtained accurately reflect the population, the acceptable margin of error, and the type of analysis to be conducted all play a role in determining the sample size. Due to the restrictions listed above, the actual sample size is frequently more of a matter of opinion than of computation.

In quantitative research, variable coding is essential for more accurate result interpretation. Microsoft Excel software was used to code and input the questions and answers into the computer. In determining the costs and benefits of waste-to-energy recovery generation (ReGen) in Nigeria, the cost-benefit method was applied to examine objective two of this study. Key officials in the waste management and energy industries were approached for economic and technical information about ReGen during expert workshops and interviews. The benefit-cost ratio, internal rate of return, and net present value are some of the most popular ways to do this. All three of these methods serve as indicators of economic profitability. One of the most contentious topics in cost-benefit analysis, the choice of discount rate frequently affects whether a project is profitable or not. Organic Rankine Cycle (ORC) is the method governing the ReGen. A close containerized thermodynamic cycle concept, used for producing power from waste with low-medium-high heat sources of between 80 and 400 degree centigrade. Its principle of operation is just like a steam cycle process, where heat from waste is employed for the evaporation of organic fluid via an expander that drives a generator to produce the required clean energy. The clean energy generated depicts clean environment with its attendant benefits, where waste heat is captured for mechanical cum electrical power. This reduces fossil-fuel dependency and/or improves energy efficiency (Eckrohrkessel, 2018). The study objective 3, the connection among waste-to-energy, environmental quality, and sustainable development in Nigeria was determined by analyzing secondary data from 1981 to 2017. To examine this nexus, Autoregressive distributive lag (ARDL) was employed.

Wen-Cheng (2017) used the ARDL technique of co-integration to research the connection between Nigeria's economic growth, energy consumption, and greenhouse gas emissions. (Pesaran et al. 2001). The model was defined as follows:

$$\mathbf{GHGi_t = \beta_0 + \beta_1 ENU_{it} + \beta_2 GDP_{it} + \beta_3 GDP^2_{it} + U_{it}} \quad \text{...} (3.1)$$

Where: GHG denotes Greenhouse Gas Emissions per Capita, ENU is energy consumption per capita. This study however, presents a modified version of the model used by Cheng (2017) to include variables stated below. The model is presented as:

$$\mathbf{GDPC = f\ (WTE, CO_2, EXC, FDI, GCF, LAB.)} \quad \text{..} (3.2)$$

Where:

GDPC	represents	GDP Per Capita
WTE	represents	Combustible Renewable and Waste
CO2	represents	Carbon Emission
EXC	represents	Exchange Rate
FDI	represents	Foreign Direct investment
GCF	represents	Gross Capital Formation
LAB	represents	Human Capital

The Autoregressive Distributive Lag (ARDL) method, created by Pesaran and Cheng (1998) and Pesaran et al., is used in this work to analyze the link between emission and energy mix (2001). Because it doesn't call for pretests for unit roots like other estimate techniques, the Autoregressive Distributive Lag (ARDL) co-integration methodology is used. Furthermore, it is more reliable when there is a single long-term link between the underlying variables in a small sample size and deals with variables that are integrated of different orders, I(0), I(1), or a mix of the two. The F-Statistics is used to identify the underlying factors' long-term relationships (Wald test).

When the F-Statistics surpasses the crucial value band, the long run relationship of the series is considered to have been established using this method. This method is helpful because it can identify co-integrating vectors in situations when there are many vectors. However, even if it is not a conditional requirement, it is recommended to test for unit roots in the context of integrated stochastic pattern of I (2) (Nkoro *et al*. 2016). Lagged values of the dependent variable and present lagged values of one or more explanatory variables are both possible regressors for the ARDL model. With the help of this model, one may ascertain the results of changing a policy variable. In its ARDL form, the model is further described as follows:

$$\Delta GDPC = \beta_0 + \beta i\Delta GDPCt - i + \beta i\Delta WTE_{t-i} + \beta i\Delta CO2_{t-I} + \beta i\Delta EXC_{t-I} + \beta i\Delta FDI_{t-I} + \beta i\Delta LAB_{t-I} + \beta i\Delta GCF_{t-I} + + \sum_{k=1}^{n} \beta i\Delta GDPC_{t-i} + \sum_{k=1}^{n} \beta i \ \Delta WTE_{t-i} + \sum_{k=1}^{n} \beta i\Delta CO2_{t-I} + \sum_{k=1}^{n} \beta i\Delta EXC_{t-I} + \sum_{k=1}^{n} \beta i\Delta FDI_{t-I} + \sum_{k=1}^{n} \beta i\Delta LAB_{t-I} + \sum_{k=1}^{n} \beta i\Delta GCF_{t-I} + + \mathbf{U_{it}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3.3)$$

The error correction model IS expressed below:

$$\Delta GDPC = \beta_0 + \sum_{k=1}^{n} \beta i\Delta GDPCC_{t-i} + \sum_{k=1}^{n} \beta i \ \Delta WTE_{t-i} + \sum_{k=1}^{n} \beta i\Delta CO2_{t-I} + \sum_{k=1}^{n} \beta i\Delta EXC_{t-I} + \sum_{k=1}^{n} \beta i\Delta FDI_{t-I} + \sum_{k=1}^{n} \beta i\Delta LAB_{t-I} + \sum_{k=1}^{n} \beta i\Delta GCF_{t-I} + \Theta_i ECM_{t-1} + \mathbf{U_{it}} \quad \ldots\ldots\ldots\ldots\ldots......(3.4)$$

3.4 Data Requirements and Sources

The information needed for this project comes from both primary and secondary sources. Residents, employees, and other important stakeholders in the Southwestern Nigerian States near large dumpsites or landfill areas were surveyed to collect primary data. Information from respondents was also gathered through direct observations and well-structured interviews. Through interviews and/or expert seminars, complementary secondary data were gathered from employees and an executive of the waste management companies and institutions. The impact of waste-to-energy or waste management on environmental quality and socioeconomic development in Southwestern Nigeria States around large dumpsites or landfill locations was the subject of in-person interviews using a well-structured interview guide and questionnaire. The interviews were done in order to get precise and trustworthy data as well as because they provided an opportunity to go deeper and address respondents' ambiguities.

Residents, employees, and other important stakeholders (respondents) in the Southwestern Nigerian States near major dumpsite or landfill areas were given questionnaires as part of the research instrument at random. A simple random sample method was used to achieve the goal of this research, taking into account the number of respondents who made up the study's population. Owning to the fact that the respondents are homogeneous and everyone has an equal probability of being chosen, this sampling procedure was adopted (Jimoh and Olorunfemi, 2005). The respondents were chosen using a stratified random sample technique for better coverage and less expense. A total of 210 homes, including residents, employees, and other waste-to-energy stakeholders near major dumpsites or landfills in all of the Southwestern Nigerian States, were chosen using the stratified random sampling technique. The amount of assurance that the features of the data obtained accurately reflect the population, the acceptable margin of error, and the type of analysis to be conducted, all play a role in determining the sample size.

Due to the restrictions listed above, the actual sample size is frequently more of a matter of opinion than of computation. Years 1981 to 2017 are covered by the secondary data source and variable descriptions. Table 3.1 lists the study's data and their sources.

Table 3.1. Data Source Variables Description

S/N	Variables	Description	Unit of Measurement (US$ in Billion)	Source	Theoretical Expectations
1	GDPC	GDP Per Capita	Billion US$	WDI	
2	WTE	Combustible Renewable and Waste	% of total final energy consumption	World Development Indicator (WDI)	Positive (+)
3	CO_2	Carbon Emission	Kt	WDI	Negative (-)
4	EXC	Exchange Rate	Real %	WDI	Negative (-)
5	FDI	Foreign Direct Investment	2010 US$ in billion	WDI	Positive (+)
6	GCF	Gross Capita Formation	Constant 2010 US$	WDI	Positive (+)
7	LAB (HDI)	Human Capital Development Index	Constant 2010 US$	WDI	Positive (+)

Source: Researcher’s Compilation

The theoretical frameworks establish a nexus between waste-to-energy, environmental quality, and sustainable development in Nigeria in order to examine the techno-economic and environmental assessment of waste-to-energy development in Nigeria. Wen-Cheng (2017) used the ARDL approach to cointegration to study the connection between Nigeria's economic development, energy consumption, and greenhouse gas emissions. (Pesaran et al. 2001). The model was defined as follows:

$$\mathbf{GHGi_t = \beta_0 + \beta_1 ENU_{it} + \beta_2 GDP_{it} + \beta_3 GDP^2_{it} + U_{it}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

Where GHG denotes Greenhouse Gas Emissions per Capita, ENU is energy consumption per capita. This study however, presents a modified version of the model used by Cheng (2017) to include variables such as the models are presented as:

SD = f (WTE, EF, GNNI, HDI) ……………………………………………....... (3.6)

EQ = f (WTE, FOSS, Y, ENE, CAP, URB, TRA, LQI) ……………………….... (3.7)

Where;

SD	Represents	Sustainable Development
EQ	Represents	Environmental Quality
WTE	Represents	Waste to Energy
EF	Represents	Environmental Footprint
GNNI	Represents	Green National Net Income
HDI	Represents	Human Development Index
FOSS	Represents	Fossil Energy Consumption
Y	Represents	Per Capita Income
ENE	Represents	Energy Consumption
CAP	Represents	Capital Investment
URB	Represents	Urbanization
TRA	Represents	Trade Intensity
LQI	Represents	Land Quality Index

The method used in the study is known as ARDL, and it was pioneered by Pesaran and Smith (1998) and Pesaran *et al* (2001), to analyze the link between emission and energy mix. Since it does not call for pretests for unit roots like other estimate techniques, the Autoregressive Distributive Lag (ARDL) co-integration methodology is used. Furthermore, it is more reliable when there is a single long-term link between the underlying variables in a small sample size and deals with variables that are integrated of different orders, I (0), I (1), or a combination of the two. The F-Statistics is used to identify the underlying factors' long-term relationships (Wald test). When the F-Statistics surpasses the crucial value band, the long run relationship of the series is considered to have been established using this method. This method is helpful because it can identify co-integrating vectors in situations when there are many vectors. However, even if it is not a conditional requirement, it is recommended to test for unit roots in the context of integrated stochastic pattern of I (2) (Nkoro *et al*. 2016). Lagged values of the dependent variable and present lagged values of one or more explanatory variables are both possible regressors for the ARDL model. With the help of this model, one may ascertain the results of changing a policy variable. The model is further specified in its ARDL form as:

$$\Delta SD = \beta_0 + \beta i \Delta SDt - i + \beta i \Delta WTE_{t-i} + \beta i \Delta EF_{t-I} + \beta i \Delta GNNI_{t-I} + \beta i \Delta HDI_{t-I} + \sum_{k=1}^{n} \beta i \Delta SD_{t-i} + \sum_{k=1}^{n} \beta i \, \Delta WTE_{t-i} + \sum_{k=1}^{n} \beta i \Delta EF_{t-I} + \sum_{k=1}^{n} \beta i \Delta GNNI_{t-I} + \sum_{k=1}^{n} \beta i \Delta HDI_{t-I} + \mathbf{U_{it}} \quad \text{......(3.8)}$$

$$\Delta EQ = \beta_0 + \beta i \Delta EQt - i + \beta i \Delta WTE_{t-i} + \beta i \Delta FOSS_{t-I} + \beta i \Delta Y_{t-I} + \beta i \Delta ENE_{t-I} + \beta i \Delta URB_{t-i} + \beta i \, \Delta CAP_{t-I} + \beta i \, \Delta TRA_{t-i} + \beta i \, \Delta LQI_{t-i} + \sum_{k=1}^{n} \beta i \, \Delta EQ_{t-i} + \sum_{k=1}^{n} \beta i \, \Delta WTE_{t-i} + \sum_{k=1}^{n} \beta i \Delta FOSS_{t-I} + \sum_{k=1}^{n} \beta i \Delta Y_{t-I} + \sum_{k=1}^{n} \beta i \Delta ENE_{t-I} + \sum_{k=1}^{n} \beta i \Delta URB_{t-I} + \sum_{k=1}^{n} \beta i \Delta CAP_{t-I} + \sum_{k=1}^{n} \beta i \Delta TRA_{t-I} + \sum_{k=1}^{n} \beta i \Delta LQI_{t-I} + \mathbf{U_{it}} \quad \text{......(3.9)}$$

The error correction model IS expressed below:

$$\Delta SD = \beta_0 + \sum_{k=1}^{n} \beta i \, \Delta SD_{t-i} + \sum_{k=1}^{n} \beta i \, \Delta WTE_{t-i} + \sum_{k=1}^{n} \beta i \, \Delta EF_{t-I} + \sum_{k=1}^{n} \beta i \, \Delta GNNI_{t-I} + \sum_{k=1}^{n} \beta i \Delta HDI_{t-I} + \Theta_i ECM_{t-1} + \mathbf{U_{it}} \quad \text{......(3.10)}$$

$$\Delta EQ = \beta_0 + \sum_{k=1}^{n} \beta i \, \Delta EQC_{t-i} + \sum_{k=1}^{n} \beta i \, \Delta WTE_{t-i} + \sum_{k=1}^{n} \beta i \, \Delta FOSS_{t-I} + \sum_{k=1}^{n} \beta i \, \Delta Y_{t-I} + \sum_{k=1}^{n} \beta i \Delta ENE_{t-I} + \sum_{k=1}^{n} \beta i \Delta URB_{t-I} + \sum_{k=1}^{n} \beta i \Delta CAP_{t-I} + \sum_{k=1}^{n} \beta i \Delta TRA_{t-I} + \sum_{k=1}^{n} \beta i \Delta LQI_{t-I} + \Theta_i ECM_{t-1} + \mathbf{U_{it}} \quad \text{......(3.11)}$$

CHAPTER FOUR
RESULTS AND DISCUSSION

The outcomes of data analyses are presented in this chapter along with their discussion. Considering the three specific objectives of this doctoral research work, (I) examining the spatial variation, challenges and prospects of waste management practices in SW-Nigeria, (II) determining the cost and benefit of waste-to-energy recovery generation (ReGen) technology in Nigeria, and (III) investigating the impact - relationship of waste-to-energy, environmental quality and sustainable development in Nigeria, this section presents the results of my findings in three major sections of descriptive stylized facts in results and discussion of primary data analysis, cost-benefit analysis and secondary data analysis.

4.1 Waste Management Practices in Nigeria (Primary Data Results and Discussion)

This descriptive statistics results and discussion covers information collected from two hundred and ten (210) households in different locations: Lagos, Ogun, Oyo, Osun, Ondo and Ekiti (all in Southwest Nigeria), and forty (40) households in Ghana (Accra, Legon and Pantang), were sieved to know the Techno-Economic Environmental Assessment of Waste-to-Energy Development. The demographic information obtained from the respondents include: Gender (*male* or *female*), Age, Marital status (*single*, *married, divorced, Separated or others*), Highest level of education (*no formal education*, *primary*, *secondary*, *tertiary or others*), Household size, Type of household size (*1-room apartment, flat, bungalow, duplex, Terrence or others*), Monthly income *(<18k, 18-30k, 31-40k, 41-50k, 51-70k, 71-90k, 91-100k or 100k+),* occupation status aside from regular work.

Section A: Demographic Characteristics of the Respondents for all the 7 Locations

Table 4.1. Location Distribution of the Respondents

Locations	Frequency	Percentage
Ekiti	30	12.0
Lagos	64	25.6
Ghana	40	16.0
Osun	30	12.0
Oyo	30	12.0
Ogun	30	12.0
Ondo	26	10.4
Total	250	100.0

It was observed (Table 4.1) that Lagos has the highest number of respondents with 25.6% (n= 64), Ghana 16% (n=40) while each of Ekiti, Osun, Oyo and Ogun has equal number of respondents with 12% (n=30) and Ondo has the lowest number of respondents with 10.4% (n=26).

It was observed (Table 4.2), most of our respondents are males representing 54.4% (n=136) of the entire respondents, 45.6% (n=114) of the respondents are females.

It was observed (Table 4.3) that 10.4% of the respondents were <18yrs; 25.6% of the respondents were between 25-29yrs; 16.4% of the respondents were between 30-34yrs; 14.4% of the respondents were between 35-39yrs; 11.6% of the respondents were between 40-44yrs; 9.6% of the respondents were between 45-49yrs; 8.4% of the respondents were between 50-54yrs; 2.8% of the respondents were between 55-59yrs; while 0.4% of the respondents were between 60-64yrs and 70yrs+.

It was observed (Table 4.4) that 64.0% of the respondents were married, 34.4% of the respondents were single; 0.8% of the respondents were divorced; while 0.4% of the respondents were either separated or belong to other marital status. This shows majority of the respondents were married.

It was observed (Table 4.5) that 6.0% (n=15) of the respondents had primary school certificate as their highest level of education, 21.6% (n=54) of the respondents had secondary school certificate as their highest level of education and 68.4% (n=171) of the respondents had tertiary institutions certificate as their highest level of education while 4.0% (n=10) of the respondents had others certificate as their highest level of education. Therefore, majority of the respondents had tertiary certificate as their highest level of education, as at the time of the research (data collection period).

Table 4.2. Gender Distribution of the Respondents

Gender	Frequency	Percentage
Male	136	54.4
Female	114	45.6
Total	250	100.0

Table 4.3. Age Distribution of the Respondents

Age	Frequency	Percent
<18yrs	26	10.4
25-29yrs	64	25.6
30-34yrs	41	16.4
35-39yrs	36	14.4
40-44yrs	29	11.6
45-49yrs	24	9.6
50-54yrs	21	8.4
55-59yrs	7	2.8
60-64yrs	1	.4
70yrs+	1	.4
Total	250	100.0

Table 4.4. Marital Status of the Respondents

Marital Status	Frequency	Percent
Married	160	64.0
Single	86	34.4
Divorced	2	.8
Separated	1	.4
Others	1	.4
Total	250	100.0

Table 4.5. Highest Level of Education of Respondents

Highest Level of Education	Frequency	Percent
Primary	15	6.0
Secondary	53	21.2
Tertiary	172	68.8
Others	10	4.0
Total	250	100.0

Table 4.6. Household Size of the Respondents

Household Size	Frequency	Percent
1	18	7.2
2	26	10.4
3	23	9.2
4	54	21.6
5	49	19.6
6	38	15.2
7	19	7.6
8	11	4.4
9	1	.4
10	1	.4
11	1	.4
12	1	.4
None	8	3.2
Total	250	100

It was observed from (Table 4.6) that 7.2% of the respondents had household size of 1; 10.4% of the respondents had household size of 2; 9.2% of the respondents had household size of 3; 21.6% of the respondents had household size of 4; 19.6% of the respondents had household size of 5; 15.2% of the respondents had household size of 6; 7.6% of the respondents had household size of 7; 4.4% of the respondents had household size of 8; 0.4% of the respondents had household size of 9,10,11,12; while 3.2% respondents fail to respond to the question. This shows that majority of the respondents had household size of 4.

The household type of all respondents across all locations was taken into consideration (Table 4.7), where it was found that 8.8% of respondents live in 1-Room Apartments, 47.2% of respondents live in Flats, 34.4% of respondents live in Bungalows, 6.4% of respondents live in Duplexes, 0.4% of respondents live in Terrence, and 2.8% of respondents live in other types of households.

The above (Table 4.8) shows the monthly income of the respondents in which it was observed that 2.4% earn <18k monthly; 14.0% earn 18-30k monthly; 4.8% earn 31-40k monthly; 8.4% of the respondents earn 41-50k monthly; 16% of the respondents earn 51-70k monthly; 11.6% of the respondents earn 71-90k monthly; 6.8% of the respondents earn 91-100k monthly; while 36.0% earn 101+k monthly. Therefore, this implies majority of this respondents earn more than one hundred and one thousand naira monthly. Where "k" means thousand naira (₦).

Table 4.7. Types of Household of the Respondents

Types of Household	Frequency	Percent
1-Room Apartment	22	8.8
Flat	118	47.2
Bungalow	86	34.4
Duplex	16	6.4
Terrence	1	.4
Others	7	2.8
Total	250	100.0

Table 4.8. Monthly Income of the Respondents

Monthly Income	Frequency	Percent
<18k	6	2.4
18-30k	35	14.0
31-40k	12	4.8
41-50k	21	8.4
51-70k	40	16.0
71-90k	29	11.6
91-100k	17	6.8
101+k	90	36.0
Total	250	100.0

Table 4.9. Respondents Occupation apart from Regular Work

Other Occupation	Frequency	Percent
Yes	126	50.4
No	124	49.6
Total	250	100.0

Table 4.10. Types of occupation of the Respondents apart from Regular Work

Types of Occupation	Frequency (T=125)	Percent (100 %)
Barbing Salon	2	1.6
Computer Engineering	1	0.8
Construction Contractor	1	0.8
Consultancy	4	3.2
Cyber cafe	1	0.8
Electrical Installation	2	1.6
Event Planning	1	0.8
Farming	22	17.6
Food selling / Eatery	2	1.6
Hair Dressing	4	3.2
Home Teaching	1	0.8
Laundry	2	1.6
Logistics Business	2	1.6
Manufacturing	1	0.8
Marketing	2	1.6
Motorcycle Driving	11	8.8
Oil Business	1	0.8
Phone Engineering	1	0.8
Real Estate Management	3	2.4
Researching	6	4.8
Scavenging Business	4	3.2
Shoe Marking	1	0.8
Sport Business	1	0.8
Supermarket and Interior Decoration	3	2.4
Tailoring	3	2.4
Trading	38	30.4
Tricycle Riding	1	0.8

It was observed (Table 4.9) that 50.4% (n=126) of the respondents deal with other occupation apart from their regular work while 49.6 (n=124) do not deal with other occupation apart from their regular work. It was observed from (Table 4.10), that 125 respondents out of 250 respondents deal with other business aside from their regular work in which 1.6% of the respondents had barbing salon business apart from their regular work; 0.8% of the respondents had computer engineering and contractor business apart from their regular work; 3.2% of the respondents had consultancy business apart from their regular work; 0.8% of the respondents had cyber café and event planning business apart from their regular work; 1.6% of the respondents had electrical installation and food selling / eatery business apart from their regular work; 17.6% of the respondents had farming business apart from their regular work.

However, 3.2% of the respondents had hair dressing business apart from their regular work; 0.8% of the respondents had home teaching and manufacturing business apart from their regular work; 1.6% of the respondents had laundry, logistics business and marketing business apart from their regular work; 8.8% of the respondents are motorcycle riders apart from their regular work; 0.8% of the respondents had phone engineering and oil business apart from their regular work; 3.4% of the respondents deal with real estate management business apart from their regular work; 4.8% of the respondents are researchers; 3.2% of the respondents had Scavenging business apart from their regular work; 0.8% of the respondents had shoe making business, sport business and tricycle riding apart from their regular work; 2.4% of the respondents had supermarket and interior decoration as business apart from their regular work; 2.4% of the respondents had tailoring business apart from their regular work; while 30.4% of the respondents are traders apart from their regular work. Therefore, this implies that 30.4% (n=38 out of 125) of the respondents in all the 7 locations deal with trading business apart from their regular work.

Section B: Demographic Characteristics of the Respondents in Southwestern Nigeria

Table 4.11. Gender Distribution of the Respondents

Gender	Frequency	Percent
Male	112	53.3
Female	98	46.7
Total	210	100.0

Table 4.12. Age Distribution of the Respondents

Age	Frequency	Percent
<18yrs	23	11.0
25-29yrs	57	27.1
30-34yrs	33	15.7
35-39yrs	30	14.3
40-44yrs	24	11.4
45-49yrs	20	9.5
50-54yrs	16	7.6
55-59yrs	6	2.9
70+	1	.5
Total	210	100.0

The total respondents from Nigeria (Lagos, Osun, Ogun, Ondo, Ekiti and Oyo) is 210 in which it was observed (Table 4.11) that 113(53.3%) of the respondents are males while 98(46.7%) are females. This implies that there are more male respondents in South West Nigeria than females with difference of 6.7%.

It was observed (Table 4.12) that 11.0% of the respondents were <18yrs; 27.1% of the respondents were between 25-29yrs; 15.7% of the respondents were between 30-34yrs; 14.3% of the respondents were between 35-39yrs; 11.4% of the respondents were between 40-44yrs; 9.5% of the respondents are between 45-49yrs; 7.6% of the respondents were between 50-54yrs; 2.9% of the respondents were between 55-59yrs; while 0.5% of the respondents were above 70yrs.

According to Table 4.13, 61.0% of respondents are married, compared to 37.1% who are single, 1% who are divorced, and 0.5% who are either separated or have another marital status. This demonstrates that the majority of respondents were married at the time the data was collected.

Table 4.14 shows the highest level of education in Nigeria (SW) in which it was observed that 7.1% of the respondents had primary school certificate as their highest level of education; 21.9% of the respondents had secondary school certificate as their highest level of education; 66.7% of the respondents had tertiary certificate as their highest level of education; while 4.8% of the respondents had others certificate as their highest level of education Therefore this implies that majority of the respondents had tertiary certificate as their highest level of education and this will reflect the good attitudes towards waste management in Nigeria (Southwestern).

Table 4.13. Marital Status of the Respondents

Marital Status	Frequency	Percent
Married	128	61.0
Single	78	37.1
Divorced	2	1.0
Separated	1	.5
others	1	.5
Total	210	100.0

Table 4.14. Highest Level of Education of Respondents in SW-Nigeria

Highest Level of Education	Frequency	Percent
Primary	15	7.1
Secondary	45	21.4
Tertiary	140	66.7
Others	10	4.8
Total	210	100.0

It was observed from (Table 4.15) that 8.1% of the respondents live in household size of 1; 9.5% of the respondents live in household size of 2; 9.0% of the respondents live in household size of 3; 22.4% of the respondents live in household size of 4; 20.5% of the respondents live in household size of 5; 11.9% of the respondents live household size of 6; 7.6% of the respondents live in household size of 7; 5.2% of the respondents live in household size of 8; 0.5% of the respondents live in household size of 9,10,11,12; while 3.8% respondents fails to respond to the question. This shows that majority of the respondents in SW-Nigeria live in household size of 4.

Table 4.16 shows the type household of all the respondents across all the locations in Nigeria (SW) in which it was observed that 8.6% of the respondents live in 1-Room Apartment; 45.7% of the respondent's lives in Flat; 36.7% of the respondent's live in Bungalow; 6.7% of the respondents lives in Duplex; 0.5% of the respondent's live in Terrence; while 1.9% of the respondents live in other type of household. This shows that majority of the respondents live in Flat.

The above (Table 4.17) shows the monthly income of the respondents in which it was observed that 2.9% of the respondents earned <18k monthly; 14.3% of the respondents earned 18-30k monthly; 4.8% of the respondents earned 31-40k monthly; 10.0% of the respondents earned 41-50k monthly; 19.0% of the respondents earned 51-70k monthly; 12.4% of the respondents earned 71-90k monthly; 6.7% of the respondents earned 91-100k monthly; while 63.0% of the respondents earned 101+K monthly. Therefore, this implies majority of this respondents earned above one hundred and one thousand naira monthly, as at the time of data collection. Where "k" means thousand naira (₦).

Table 4.18 shows the respondents occupation apart from regular work in which it was observed that 53.3% of the respondents deal with other occupation apart from their regular work while 46.7% of the respondents do not deal with other occupation apart from their regular work. This implies that only 112 respondents out of 210 Nigeria (South West) respondents with 53.3% have other occupations apart from their regular work.

Table 4.15. Household Size of the Respondents

Household Size	Frequency	Percent
1	17	8.1
2	20	9.5
3	19	9.0
4	47	22.4
5	43	20.5
6	25	11.9
7	16	7.6
8	11	5.2
9	1	.5
10	1	.5
11	1	.5
12	1	.5
None	8	3.8
Total	210	100

Table 4.16. Types of Household of the Respondents

Types of Household	Frequency	Percent
1-Room Apartment	18	8.6
Flat	96	45.7
Bungalow	77	36.7
Duplex	14	6.7
Terrence	1	.5
Others	4	1.9
Total	210	100.0

Table 4.17. Monthly Income of the Respondents

Monthly Income (₦)	Frequency	Percent (%)
<18k	6	2.9
18-30k	30	14.3
31-40k	10	4.8
41-50k	21	10.0
51-70k	40	19.0
71-90k	26	12.4
91-100k	14	6.7
101+k	63	30.0
Total	210	100.0

Table 4.18. Respondents Occupation apart from Regular Work

Other Occupation	Frequency	Percent (%)
Yes	112	53.3
No	98	46.7
Total	210	100.0

Table 4.19. Types of Occupation of Respondents apart from Regular Work

Types of Occupation	Frequency	Percent (%)
Barbing Salon	2	1.0
Computer Engineering	1	.5
Construction Contractor	1	.5
Consultancy	3	1.4
Electrical Installation	2	1.0
Event Planning	1	.5
Farming	18	8.6
Food Selling / Eatery	2	1.0
Hair Dressing	4	1.9
Home Teaching	1	.5
Laundry	1	.5
Logistics Business	2	1.0
Manufacturing	1	.5
Marketer	2	1.0
Motorcycle Riding	11	5.2
Barber	2	1.0
Oil Business	1	.5
Phone Engineering	1	.5
Real Estate	3	1.4
Researching	5	2.4
Sand Supplying	1	.5
Scavenging Business	4	1.9
Shoe Making	1	.5
Sport Business	1	.5
Supermarket and Interior Decoration	3	1.4
Tailoring	3	1.4
Trading	36	17.1
Tricycle Riding	1	.5
No Response	98	46.7
Total	**210**	**100.0**

It was observed from (Table 4.19), that 112 respondents out of 210 respondents deal with other business aside from their regular work in which 1.0% of the respondents had barbing salon business apart from their regular work; 0.5% of the respondents had computer engineering and construction business apart from their regular work; 1.4% of the respondents had consultancy business apart from their regular work; 0.5% of the respondents had event planning business apart from their regular work; 1.0% of the respondents had electrical installation and food selling / eatery business apart from their regular work; 8.6% of the respondents had farming business apart from their regular work; 1.9% of the respondents had hair dressing business apart from their regular work; 0.5% of the respondents had home teaching, laundry and manufacturing business apart from their regular work; 1.0% of the respondents had logistics and marketing businesses apart from their regular work; 5.2% of the respondents are motorcycle riders apart from their regular work; 0.5% of the respondents had phone engineering business, sand supplying business and oil business apart from their regular work.

However, 1.4% of the respondents deal with real estate management business apart from their regular work; 2.4% of the respondents are researchers; 1.4% of the respondents had scavenging business apart from their regular work; 0.5% of the respondents had shoe making business, sport business and tricycle riding apart from their regular work; 1.4% of the respondents had super market and interior decoration as businesses apart from their regular work; 1.4% of the respondents had tailoring business apart from their regular work; while 17.1% of the respondents have trading business apart from their regular work. Therefore, this implies majority of the respondents in Nigeria (Southwest) deal with trading business apart from their regular work.

Section C: Argument on Waste to Energy in Nigeria (SW)

Table 4.20 A&B: Types and Categories of Waste Disposed/Generated in Nigeria (SW) respectively

Variables	Frequency	Percent (%)
Domestic Solid Waste	204	97.1
Industrial Solid Waste	6	2.9
Total	210	100.0

Table 4.20B.

Variables	Frequency	Percent (%)
Plastic	23	11.0
Paper	8	3.8
Agric / Food	44	21.0
Other Waste: used utensils / electronics	4	1.9
Plastic and paper	69	32.9
Plastic, paper and Agric food	62	29.5
Total	210	100.0

It was observed (Table 4.20a) that 97.1% of waste disposed/generated by the respondents of Nigeria (SW) are domestic solid waste, while 2.9% of waste disposed/generated by the respondents of Nigeria (Southwest) are industrial solid waste. This indicates that majority of waste disposed/generated by the respondents of Nigeria (SW) are domestic solid waste.

It was observed (Table 4.20b) that 11.0% of the respondents generated plastic as source waste 3.8% of the respondents generated paper as source of waste; 21.0% of the respondents generated agric/food as source of waste, 1.9% of the respondents generated other waste used utensils/electronic as source of waste, 32.9% of the respondents generated plastic and paper as source of waste while 29.5% of the respondents generated plastic, paper and agric/food as source of waste. This shows plastic and paper are the real source of waste in Nigeria (SW).

It was observed (Table 4.21) that 33.3% of the respondents made use of Refuse bin as waste disposal options; 13.3% of the respondents made use of dumpsite, 46.2% of the respondents made use of private collection as waste disposal options; 4.8% of the respondents made use of indiscriminate dumping as waste disposal options while 2.4% of the respondents made use of specified dump point as waste disposal options. This shows that majority of respondents in Nigeria (SW) made use of private collection as waste disposal options and this will prevent them from health challenges. It was observed (Table 4.22) that 28.1% of the respondents always separated their waste at source while 71.9% of the respondents do not separated their waste at source. This shows that majority of the respondent do not separated their waste at source due to lack of knowledge about waste separation.

Table 4.21. Waste Disposal Options Available in Nigeria (SW)

Waste Disposal Options	Frequency	Percent (%)
Refuse Bin	70	33.3
Dumpsite	28	13.3
Private Collection	97	46.2
Indiscriminate Dumping	10	4.8
Specified Dump Point	5	2.4
Total	210	100.0

Table 4.22 A, B & C: Response about Separation of Waste and Response on If No and If Yes Why Not Separating Waste at Source in Nigeria (SW), respectively

Do you separate your waste	Frequency	Percent (%)
Yes	59	28.1
No	151	71.9
Total	210	100.0

Table 4.22B.

If No Why	Frequency	Percent (%)
Time wasting/Not Necessary	65	31.0
No Provision/Encouragement	86	41.0
No Response	59	28.1
Total	210	100.0

Table 4.22 C

If Yes Why	Frequency	Percent (%)
Helps Waste Management	59	28.1
Others	0	0.0
No response	151	71.9
Total	210	100.0

Table 4.23 Perception on Waste Management and Separation in Nigeria (SW)

Variables	Frequency	Percent (%)
1. Perception on waste separation		
Right	179	85.2
Wrong	14	6.7
Undecided	17	8.1
Total	210	100.0
2. Perception on landfill/open & Indiscriminate dumping		
Right with minimal consequence	36	17.1
Wrong with grave consequence	140	66.7
Undecided	34	16.2
Total	210	100.0

It was observed (Table 4.22a) that 71.9% of the respondents do not separate their waste at source and It was stated (Table 4.22b) that 31.0% of the respondents do not separate their waste at source because they see it as time wasting / not necessary while 41.0% of the respondents said that there is no provision/encouragement for separation of waste at source in Nigeria (SW).

It was observed (Table 4.22c) that 28.1% of the respondents separated their waste at source in order to help waste management in their area. Table 4.23 shows the perception on waste management and separation in Nigeria (SW), majority of the respondents 179 (85.2%) of the respondents agree that perception on waste separation are right; 14 (6.7%) of the respondents said that perception on waste separation are wrong while 17 (7.8%) of respondents were undecided about perception on waste separation. 36 (17.1%) of the respondents said perception on landfill/open and indiscriminate dumping were right with minimal consequence; majority of the respondents 140 (66.7%) said perception on land fill/open and indiscriminate dumping were wrong with grave consequence; while 34 (16.2%) of the respondents were undecided on perception on landfill/open and indiscriminate dumping. This implies that majority of the respondents in Nigeria (SW) know the effect of indiscriminate dumping which can lead to health challenges in the society.

It was observed (Table 4.24) that 38.1% of the respondents said that their house & working place are very close (<1km), 22.9% of the respondents said that their house & working place are Not far (1-3km) to dumpsite; while 39.0% of the respondents said that their house & working place are far (>3km) to dumpsite. This implies that majority of the respondents in Nigeria (SW) said their house & work place are far (>3km) to dumpsite which will prevent them from health challenges.

Table 4.24. Location/Source of Waste in Nigeria (SW)

How far is your house & work to dumpsite?	Frequency	Percent (%)
Very Close (<1km)	80	38.1
Not Far (1-3km)	48	22.9
Far(>3km)	82	39.0
Total	210	100.0

Table 4.25. Perception on Waste Management and Challenges in Nigeria (SW)

Variables	Frequency	Percent (%)
1. How effective is waste management in your area?		
Effective + Need Improvement	109	51.9
Not Effective + Require	78	37.1
Overhaul	19	9.0
Undecided	4	1.9
Total	210	100.0
2. Why?		
Inadequate Funding	66	31.4
Lack of Personnel	38	18.1
Lack of Equipment	56	26.7
Technological Constraints	50	23.8
Total	210	100.0
3. What are waste management styles in your area?		
PSP	47	24.2
LAWMA/Government waste management	72	34.3
None Open Disposal	16	7.6
PSP and LAWMA/Government waste management	73	34.8
PSP and None Open Disposal	2	1.0
Total	210	100.0

Table 4.25 shows perception on waste management and challenges in Nigeria (SW). It was observed that 51.9% of the respondents said waste management in their area is effective but needs improvement; 37.1% of the respondents said waste management in their area is not effective and it requires improvement; 9.0% of the respondents said waste management in their area requires overhaul; while 1.9% were undecided on perception on waste management and challenges. This shows that waste management is effective in Nigeria (SW) but it needs improvement. It was also stated in Table 8.18 that 31.4% of the respondents said that waste management is not effective in their area due to inadequate funding; 18.1% of the respondents said that waste management is not effective in their area due to lack of personnel; 26.7% of the respondents said that waste management is not effective in their area due to lack of equipment; while 23.8% of the respondents said that waste management is not effective in their area due to technological constraints. Therefore, it was observed that waste management is effective in Nigeria (SW) but it needs improvement due to inadequate funding by the government agency. Table 4.28 also shows that waste management styles used by the respondents of Nigeria (SW) in which it was observed that 34.8% of respondents said that PSP and LAWMA/Government waste management are the waste management style used in their area.

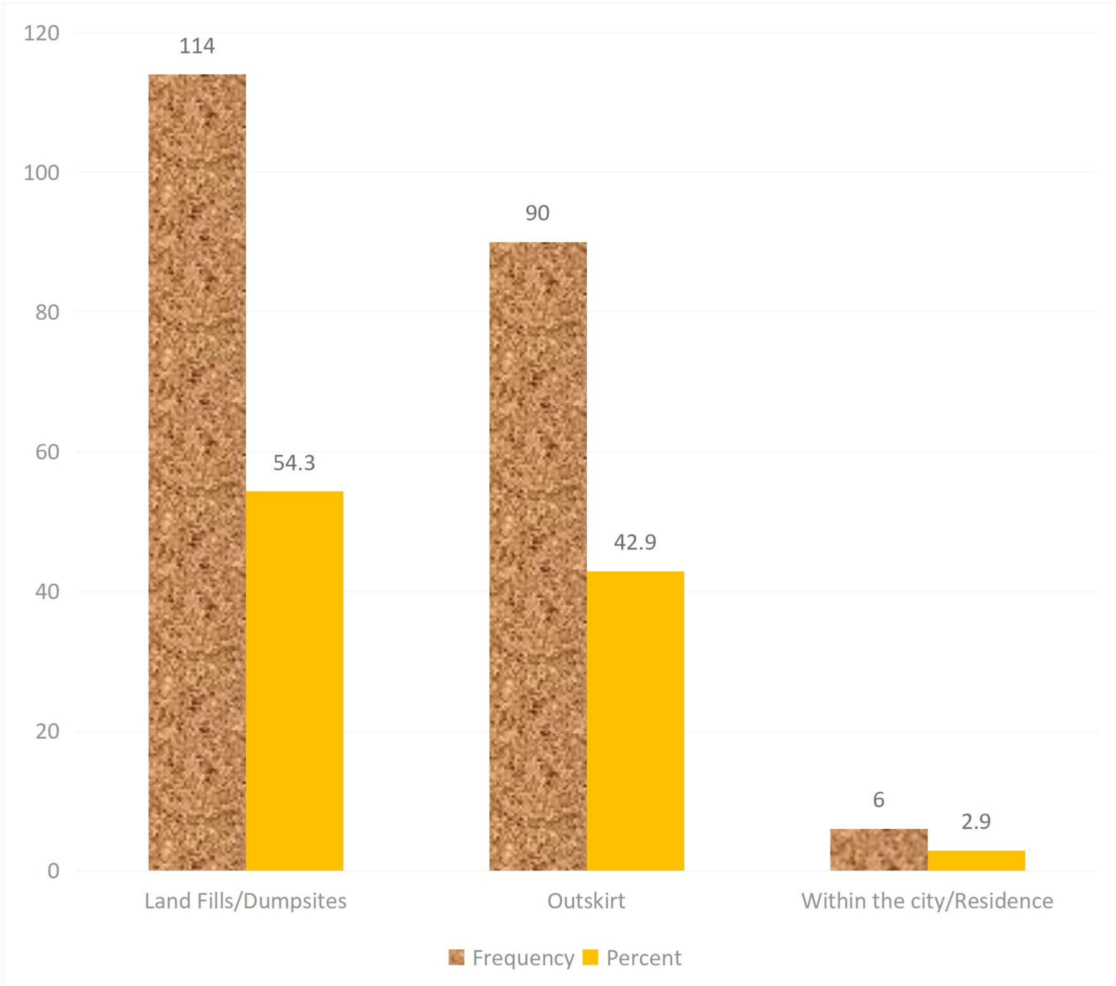


Figure 4.1. Responses on where should WTE / Waste Management be done in Nigeria (SW)

Table 4.26. Nigeria (SW) Respondents Waste Generation by rank: (1) lowest to (5) Highest

Variables	Frequency	Percent (%)
1. Plastic		
Rank 1	31	14.8
Rank 2	62	29.5
Rank 3	43	20.5
Rank 4	24	11.4
Rank 5	50	23.8
Total	210	100.0
2. Food/Agric		
Rank 1	24	11.4
Rank 2	56	26.7
Rank 3	53	25.2
Rank 4	53	25.2
Rank 5	24	11.4
Total	210	100.0
3. Paper		
Rank 1	16	7.6
Rank 2	23	11.0
Rank 3	31	14.8
Rank 4	68	32.4
Rank 5	72	34.3
Total	210	100.0
4. Waste/Hazardous		
Rank 1	93	44.4
Rank 2	54	25.7
Rank 3	21	10.0
Rank 4	31	14.8
Rank 5	11	5.2
Total	210	100.0
5. Sweepings		
Rank 1	24	11.4
Rank 2	15	7.1
Rank 3	20	9.5
Rank 4	61	29.0
Rank 5	90	42.9
Total	210	100.0

Table 4.26 shows the Nigeria (SW) waste generation by rank in which 1 is ranked as lowest and 5 is ranked as highest. 14.8% of the respondents claimed that plastic are lowest waste generated and 23.8% of the respondents claimed that plastic are highest waste generated; 11.4% of the respondents claimed that Agric / Food are lowest waste generated and 11.4% of the respondents claimed that Agric / Food are highest waste generated; 7.6% of the respondents claimed that paper are the lowest waste generated and 34.3% of the respondents claim that paper are the highest waste generated; 44.4% of the respondents claimed that waste/hazardous are the lowest waste generated and 5.2% of the respondents also claimed that waste/hazardous is highest waste generated. 11.4% of the respondents claimed that sweepings are lowest waste generated and 42.9% of the respondents also claimed that sweepings are the highest waste generated. Table 8.19 shows that sweepings are the highest waste generated in Nigeria (SW) while waste hazardous are the lowest waste generated in Nigeria (SW).

Table 4.27 shows the response of Nigeria (SW) on if they are willing to pay for waste management/WtE, in which it was observed that 94.3% of respondents in Nigeria (SW) are willing to pay for waste-to-energy / waste management because health is wealth while 5.7% of the respondents are not willing to pay because the respondents prefer to damn the consequence than to pay.

Table 4.27. Willingness to Pay for Waste-to-Energy / Waste Management in SW-Nigeria

Are you willing to pay for waste-to-energy/waste mgt?	Frequency	Percent (%)
Yes, because health is Wealth	198	94.3
No, I prefer damn the consequence than pay	12	5.7
Total	210	100.0

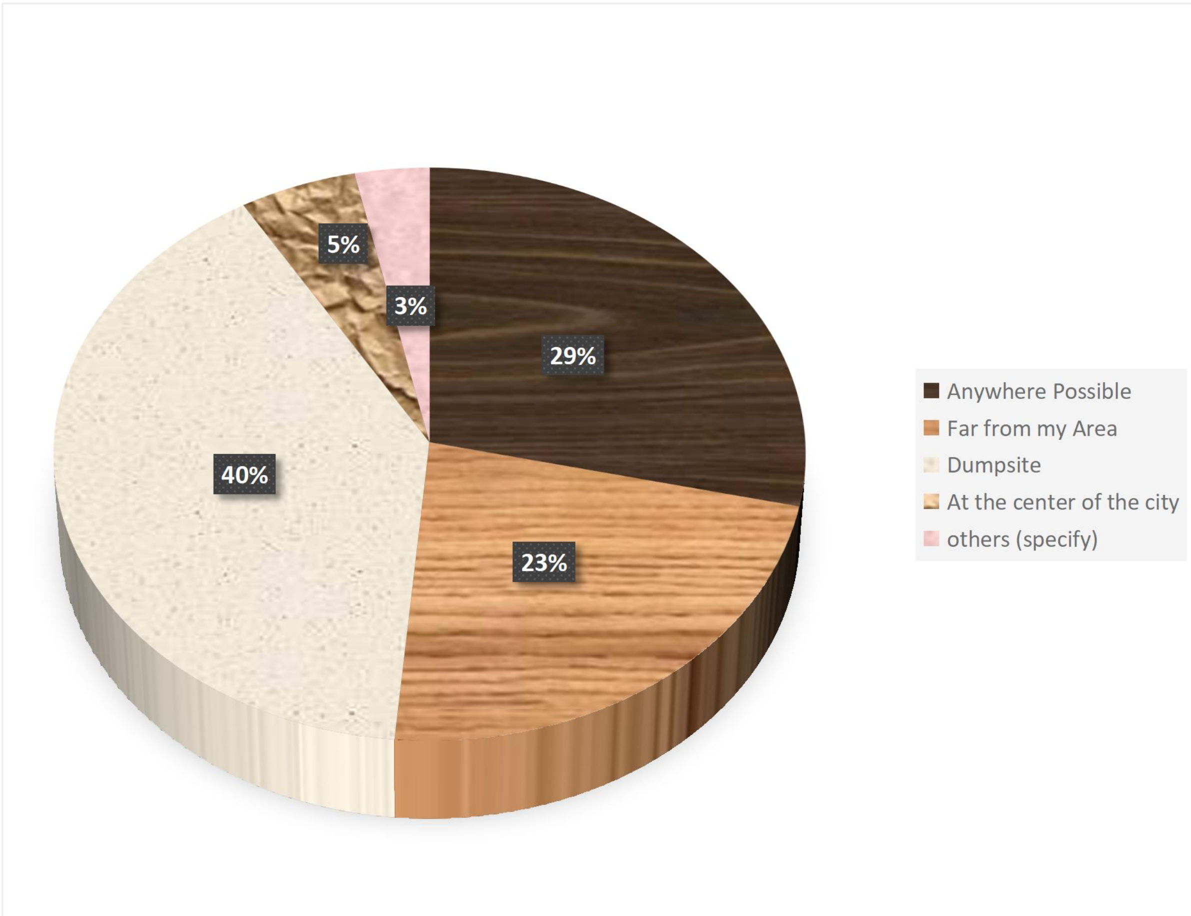


Figure 4.2. Responses on where they prefer WtE plant to be built in Nigeria (SW)

Table 4.28. Expenses on Electricity (DISCOS) on a Monthly Basis in Nigeria (SW)

How much do you spend on electricity (DISCOS / National Grid) per month? Naira = ₦	**Frequency**	**Percent (%)**
₦1,000	1	.5
₦1,500	9	4.3
₦10,000	13	6.2
₦12,000	2	1.0
₦12,500	1	.5
₦15,000	7	3.3
₦16,000	1	.5
₦17,000	1	.5
₦18,000	2	1.0
₦2,000	16	7.6
₦2,500	27	12.9
₦20,000	5	2.4
₦24,000	1	.5
₦26,000	1	.5
₦27,000	1	.5
₦28,000	1	.5
₦3,000	13	6.2
₦3,200	1	.5
₦3,500	6	2.9
₦30,000	1	.5
₦4,000	11	5.2
₦4,500	2	1.0
₦5,000	25	11.9
₦6,000	5	2.4
₦6,500	3	1.4
₦65,000	3	1.4
₦66,000	1	.5
₦7,000	9	4.3
₦8,000	7	3.3
₦9,000	3	1.4
Zero Expenses	31	14.8
Total	210	100.0

It was observed (Table 4.31) that 0.5% of the respondents spent ₦1,000, ₦3,200, ₦16,000, ₦17,000, ₦24,000, ₦26,000, ₦27,000, ₦28,000, and ₦66,000, on electricity (DISCOS) monthly; 1.0% of the respondents spent ₦4,000, ₦12,000, and ₦18,000; 1.4% of the respondents spent ₦6,500 and ₦65,000 on electricity (DISCOS) monthly; 2.4% of the respondents spent ₦6,000 and ₦20,000 on electricity (DISCOS) monthly; 2.9% of the respondents spent ₦3,500 on electricity (DISCOS) monthly; 3.3% of the respondents spent ₦15,000 and ₦8,000 on electricity (DISCOS) monthly.

However, 4.3% of the respondents spent ₦1,500 and ₦7,000 on electricity (DISCOS) monthly 5.2% of the respondents spent ₦4,000 on electricity (DISCOS) monthly, 6.2% of the respondents spent ₦3,200 and ₦10,000 on electricity (DISCOS) monthly, 7.6% of the respondents spent ₦2,000 on electricity (DISCOS) monthly, 11.9% of the respondents spent ₦5,000 on electricity (DISCOS) monthly, 12.9% of the respondents spent ₦2,500 on electricity (DISCOS) monthly, while 14.8% of the respondents doesn't pay any money on electricity (DISCOS) monthly. Therefore, this shows that majority of Nigeria (South West) respondents spent ₦2,500 on electricity (DISCOS) monthly.

Table 4.29. Expenses on Generator (Petrol/Diesel) on a Monthly Basis in Nigeria (SW)

How much do you spend monthly on generator (petrol/diesel)?	Frequency	Percent
₦ 1,500	2	1.0
₦10,000	23	11.0
₦101,000	1	.5
₦12,000	4	1.9
₦13,000	2	1.0
₦15,000	14	6.7
₦15,225	1	.5
₦150,000	1	.5
₦16,000	1	.5
₦17,500	1	.5
₦2,000	1	.5
₦2,100	1	.5
₦2,400	1	.5
₦2,500	2	1.0
₦20,000	11	5.2
₦21,000	1	.5
₦22,500	1	.5
₦25,000	4	1.9
₦3,000	5	2.4
₦3,500	1	.5
₦30,000	6	2.9
₦32,000	1	.5
₦4,000	12	5.7
₦4,500	1	.5
₦40,000	1	.5
₦45,000	1	.5
₦5,000	31	14.8
₦5,600	1	.5
₦50,000	2	1.0
₦500	2	1.0
₦55,000	2	1.0
₦6,000	12	5.7
₦6,500	1	.5
₦60,000	2	1.0
₦65,000	1	.5
₦7,000	1	.5
₦7,500	3	1.4
₦70,000	1	.5
₦700	1	.5
₦75,000	2	1.0
₦8,000	6	2.9
₦9,000	4	1.9
Zero Expenses	38	18.1
Total	210	100.0

It was observed (Table 4.29) that 1.6 % of the respondents spent ₦700, ₦2,000, ₦2,100, ₦2,400, ₦3,500, ₦4,500, ₦5,600, ₦6,500, ₦7,000, ₦16,000, ₦17,500, ₦21,000, ₦22,500, ₦32,000, ₦40,000, ₦45,000, ₦65,000, ₦70,000 and ₦101,000 on generator (petrol/diesel) monthly; 1.0% of the respondents spent ₦5,00 ₦1,500, ₦2,500, ₦13,000, ₦50,000, ₦55,000, ₦60,000, and ₦75,000 on generator (petrol/diesel) monthly; 1.4% of the respondents spent ₦7,500 on generator (petrol/diesel) monthly, 1.9% of the respondents spent ₦9,000 and ₦12,000 on generator (petrol/diesel) monthly, 2.4% of the respondents spent ₦3,000 on generator (petrol/diesel) monthly 2.9% of the respondents spent ₦8,000 and ₦30,000 on generator (petrol/diesel) monthly; 5.2% of the respondents spent ₦20,000 on generator (petrol/diesel) monthly, 5.7% of the respondents spent ₦4,000 and ₦6,000 on generator (petrol/diesel) monthly.

However, 6.7% of the respondents spent ₦15,000 on generator (petrol/diesel) monthly, 11.0% of the respondents spent ₦10,000 on generator (petrol/diesel) monthly, 14.8% of the respondents spent ₦5,000 on generator (petrol/diesel) monthly while 18.1% of the respondents had zero expenses on generator (petrol/diesel) monthly. Therefore, this shows that majority of the respondents spent ₦5,000 on generator (petrol/diesel) monthly due to instability of electricity in Nigeria (South West).

It was observed (Table 4.30) that 54.3% of the respondents said waste-to-energy / waste management should be done in landfills / dumpsite; 42.9% of the respondents said WtE / waste management should be done in outskirt while 2.9% of the respondents said WtE/waste management should be done within the city / residence. This indicates that majority of the respondents want waste-to-energy / waste management to be done on landfills / dumpsite because the waste generated from landfill / dumpsite can be easily used to produce energy.

Table 4.30. Responses on where should WTE/ Waste Management be done in Nigeria (SW)

Where WTE/ Waste management should be done?	Frequency	Percent (%)
Landfills / Dumpsites	114	54.3
Outskirt	90	42.9
Within the City / Residence	6	2.9
Total	210	100.0

Table 4.31. Responses on Waste Management and Challenges in Nigeria (SW)

Variables		Frequency	Percent
i.	**Waste Management are very challenging in my area**		
	Strongly Disagree	6	2.9
	Disagree	21	10.0
	Agree	40	19.0
	Strongly Agree	143	68.1
	Total	210	100.0
ii.	**I do experience health issues/pollution (water, air or land) from waste in my area**		
	Strongly Disagree	18	8.6
	Disagree	47	22.4
	Agree	58	28.1
	Strongly Agree	86	41.0
	Total	210	100.0

Table 4.31 shows responses on waste management and challenges in Nigeria (SW) and it was observed that 2.9% of the respondents strongly disagree that waste management is very challenging in their area; 10.0% of the respondents disagree that waste management is very challenging in their area; 19.0% of the respondents agree that waste management is challenging in their area; while 68.1% of the respondents strongly agree that waste management is challenging in their area. This shows that waste management is very challenging in Nigeria (SW) due to inadequate funding.

Table 8.24 also indicates that they do experience health issues / pollution (water, air or land) from waste in their area in which it was stated that 8.6% of the respondents strongly disagree that they do experience health issues/pollution (water, air or land) from waste in their area; 22.4% of the respondents disagree that they do experience health issues/pollution (water, air or land) from waste in their area; 28.1% of the respondents agree that they do experience health issues/pollution (water, air or land) from waste in their area; while 41.0% of the respondents strongly agree that they do experience health issues/pollution (water, air or land) from waste in their area. Therefore, this shows that majority of the respondents do experience health issues/pollution (water, air or land) from waste in their area because of lack of equipment by the waste management agency in Nigeria (SW).

Table 4.32. Health or Hazard issues Experienced from Waste in Nigeria (SW)

What are the health or hazard issues experienced from waste?	Frequency	Percent
Air pollution	37	17.6
Cough when burnt	1	.5
Malaria, cholera, typhoid fever and skin infections	38	18.1
Skin and breathing problems	1	.5
When waste collection is delayed, rodents and infection cause sickness	16	7.6
No Response	117	55.7
Total	210	100.0

Table 4.33. Nigeria (SW) Respondents on if they Farm close to Dumpsite and Why?

Variables	Frequency	Percent
Do you Farm close to Dumpsite		
Yes	36	17.1
No	174	82.9
Total	210	100.0
Why?		
For better yields	6	2.9
Health is wealth	1	1.5
Land there are cheap and fertile	27	12.8
Not a farmer	46	21.9
Not proper	3	1.4
To reduce waste smell	3	1.4
No Response	87	41.4
Total	**210**	**100.0**

Table 4.32 indicates the health or hazard issues experienced from waste in Nigeria (S West) in which it was observed that 0.5% of the respondents said cough when burnt and skin breathing problems are the health or hazard issues experienced from waste; 17.6% of the respondents said Air pollution are the health or hazard issues experienced from waste; 18.1% of the respondents said malaria, cholera, typhoid fever and skin infections are the health or hazard issues experienced from waste; 7.6% of the respondents said when waste collection is delayed, rodents and infection causing sickness are the health or hazard issues experienced from waste; while 55.7% fail to respond to this question. This shows that Malaria, cholera, typhoid fever and skin infections are the health or hazard issues experienced from waste in Nigeria (SW).

Table (4.33) shows responses on if Nigeria (SW) respondents farm close to dumpsite and why in which it was observed that 17.1% of the respondents farm close to dumpsite because land there are cheap and fertile, it will reduce waste smell in Nigeria (South West) while 82.9% of the respondents did not farm close to dumpsite because they are not farmers, not proper, and to reduce waste smell. Table 4.37 shows some electrical appliances and equipment that require electricity power in Nigeria (SW). It was observed 97.1% of the respondents use Television as electrical appliances and equipment that require electricity power; 89.0% of the respondents use refrigerator as electrical appliances and equipment that require electricity power, 94.8% of the respondents use fan as electrical appliances and equipment that require electricity power; 51.0% of the respondents use air condition as electrical appliances and equipment that require electricity power; 69.0% of the of the respondents use electric cooker as electrical appliances and equipment that require electricity power; 93.3% of the of the respondents use iron as electrical appliances and equipment that require electricity power while 61.4% of the respondents use other electrical equipment that require electricity power.

Table 4.34. Some Electrical Appliances/Equipment Require Electricity Power in Nigeria (SW)

Variables	Frequency	Percent
1. Some electrical appliances and equipment you require electricity power		
Television	204	97.1
No Response	6	2.9
Total	210	100.0
2. Some electrical appliances and equipment you use require electricity power		
Refrigerator	187	89.0
No Response	23	11.0
Total	210	100.0
3. Some electrical appliances and equipment you use require electricity power		
Air Condition	107	51.0
No Response	103	49.0
Total	210	100.0
4. Some electrical appliances and equipment you use require electricity power		
Fan	199	94.8
No Response	11	5.2
Total	210	100.0
5. Some electrical appliances and equipment you use require electricity power		
Electrical cooker	145	69.0
No Response	65	31.0
Total	210	100.0
6. Some electrical appliances and equipment you use require electricity power		
Iron	196	93.3
No Response	14	6.7
Total	210	100.0
7. Some electrical appliances and equipment you use require electricity power		
Others (bulbs, Radio etc.	129	61.4
No Response	81	38.6
Total	210	100.0

Table 4.35. Responses on if they will like wastes to be used to generate electricity (24/7) for their household and work in Nigeria (SW)

Would you like these wastes to be used to generate electricity (24/7) for your household and work?	Frequency	Percent
Yes	204	97.1
No	6	2.9
Total	210	100.0

Table 4.36. Responses on if they will support and encourage waste to energy project if introduced to save both waste and electricity problem in Nigeria (SW) and Why?

Variables	Frequency	Percent
1. Will you support & encourage waste to energy project if introduced to save both waste & electricity problem in your area		
Yes	202	96.2
No	8	3.8
Total	210	100.0
2. Why?		
Because it will give constant power supply	101	48.1
To solve waste problems, stop health challenges & save environment	51	24.3
It will create employment opportunity	35	16.7
WTE will take my scavenging job	5	2.4
No Response	18	8.6
Total	210	100.0

It was observed (Table 4.35) that 97.1% of the respondent want waste to be used to generate electricity (24/7) for their household and work while 2.9% of the respondents do not want waste to be used to generate electricity (24/7) for their household and work.

It was observed (Table 4.36) that 96.2% of the respondents in Nigeria (SW) will support and encourage waste to energy project if introduced to save both waste and electricity problem in their area because it will give constant power supply, it will create employment opportunity, solve waste problems, stop health challenges and save environment, while 2.4% do not support and encourage waste to energy project if introduced to save both waste and electricity problem in their area, because it will take their scavenging job away from them.

It was observed (Table 4.37) that 28.6% of the respondents prefer WTE plant to be built anywhere possible in their area; 22.9% of the respondents prefer WTE plant to be built far away from their area; 40.0% of the respondents prefer WTE plant to be built at the dumpsite; 5.2% of the respondents prefer WTE plant to be built at the center of the city while 3.3% of the respondents prefer WTE plant to be built elsewhere. This implies majority of the Nigeria (SW) respondents prefer WTE plant to be built at the dumpsite.

It was observed (Table 4.38) that 95.2% of the respondents are willing to pay the money they use for DISCOS and generator bills to have a consistent electricity (24/7) from WTE, while just 4.8% of the respondents are not willing to pay the money they use for DISCOS and generator bills to have a consistent electricity (24/7) from WTE. This shows that majority of the respondents in Nigeria (SW) are willing to pay the money they use for DISCOS and generator bills to have a consistent electricity (24/7) from waste-to-energy (WTE).

Table 4.37. Responses on where they prefer Waste-to-Energy plant to be built in SW-Nigeria

Where you prefer Waste-to-Energy Plant to be built in your area?	Frequency	Percent
Anywhere / Close to Dumpsite	60	28.6
Far from my Area	48	22.9
Dumpsite	84	40.0
At the Center of the City	11	5.2
Others (specify)	7	3.3
Total	210	100.0

Table 4.38. Responses on if they are willing to pay the Money used for DISCOS, Generator Bills to have a Consistent Electricity (24/7) from Waste-to-Energy in Nigeria (SW)

Will you be willing to pay the money you use for DISCOS, generator bills to have a consistent electricity (24/7) from WTE?	Frequency	Percent
Yes	200	95.2
No	10	4.8
Total	210	100.0

Table 4.39. Expenses on Wastes Disposal on a Monthly Basis Nigeria (SW)

How much do you pay for waste disposal? (# = Naira)	Frequency	Percent
#1,000	29	13.8
#1,200	1	.5
#1,500	24	11.4
#10,000	1	.5
#15,000	1	.5
#2,000	21	10.0
#2,500	15	7.1
#200	3	1.4
#250	9	4.3
#3,000	9	4.3
#300	3	1.4
#400	1	.5
#4,000	2	1.0
#4,500	1	.5
#500	5	2.4
#5,000	3	1.4
#500	15	7.1
#7,000	1	.5
#800	11	5.2
#8,000	1	.5
#9,000	1	.5
Zero Expenses	54	25.7
Total	210	100.0

Table 4.39 reveals expenses on waste disposal on a monthly basis in Nigeria (South West) 0.5% of the respondents paid #4,00, #1,200, #4,500, #7,000, #9,000, #10,000 and #15,000 on waste disposal on a monthly basis; 1.0% of the respondents paid #4,000 on waste disposal on a monthly basis; 1.4% of the respondents paid #200, #300 and #5,000 on waste disposal on a monthly basis; 2.4% of the respondents paid #500 on waste disposal on a monthly basis; 4.3% of the respondents paid #2,0 and #3,000, on waste disposal on a monthly basis; 5.2% of the respondents paid #8,00 on waste disposal on a monthly basis; 7.1% of the respondents paid #500 and #2,500 on waste disposal on a monthly basis; 10.0% of the respondents paid #2,000 on waste disposal on a monthly basis; 11.40% of the respondents paid #1,500 on waste disposal on a monthly basis;13.8% of the respondents paid #1,000 on waste disposal on a monthly basis and 25.7% of the sample do not pay anything on waste removal on a monthly basis. This shows that majority of the respondents in Nigeria (SW) paid #1,000 on waste disposal on a monthly basis.

Table 4.40 indicates responses on if they reuse, recover & recycle their waste in Nigeria (South West) in which it was observed that 34.5% of the respondents reuse, recover and recycle their waste because it serves as additional income and to reduce waste in reduce in the country while 65.7% of the respondents do not reuse, recover & recycle their waste because no provision/encouragement from the government and they also see it as waste of time.

It was observed (Table 4.41) that 68.6% of the respondents have people that work in waste management facilities in their area, while 31.4% of the respondents have no people that work in waste management facilities in their area.

Table 4.40. Responses on if they reuse, recover & recycle waste in Nigeria (SW) and why?

Variables	Frequency	Percent (%)
1. Do you rescue, recover & recycle your waste?		
Yes	72	34.3
No	138	65.7
Total	210	100.0
2. Why?		
Additional source of income	53	25.2
No provision/ encouragement from government	53	25.2
Time wasting	11	5.2
To reduce waste	10	4.7
No Response	83	39.5
Total	210	100.0

Table 4.41. Responses on if Respondents have people that work in Waste Management facilities in Nigeria (SW)

Do people work in waste management facilities in your area?	**Frequency**	**Percent (%)**
Yes	144	68.6
No	66	31.4
Total	210	100.0

Table 4.42: Average Amount Spent in a Month According to SW-Nigeria Respondents

Average amount spent in a month (Consumption) (# = Naira)	Frequency	Percent
#10,000	6	2.9
#100,000	6	2.9
#12,000	1	.5
#120,000	5	2.4
#130,000	1	.5
#15,000	11	5.2
#150,000	10	4.8
#16,000	1	.5
#160,000	1	.5
#17,000	1	.5
#180,000	2	1.0
#1million	1	.5
#2,000	1	.5
#20,000	13	6.2
#200,000	1	.5
#21,000	2	1.0
#210,000	1	.5
#22,000	1	.5
#225,000	1	.5
#240,000	1	.5
#25,000	6	2.9
#28,000	6	2.9
#3,000	1	.5
#30,000	12	5.7
#300,000	1	.5
#33,000	1	.5
#33,600	1	.5
#35,000	4	1.9
#4,000	1	.5
#40,000	10	4.8
#400,000	5	2.4
#42,000	1	.5
#43,000	2	1.0
#45,000	15	7.1

Average amount spent in a month (Consumption) (# = Naira)	**Frequency**	**Percent**
#47,000	2	1.0
#49,000	1	.5
#5,000	3	1.4
#50,000	13	6.2
#500,000	1	.5
#51,000	1	.5
#53,500	1	.5
#55,000	2	1.0
#55,200	2	1.0
#550,000	1	.5
#56,000	2	1.0
#57,000	1	.5
#6,000	2	1.0
#60,000	21	10.0
#600,000	2	1.0
#63,500	1	.5
#630,000	1	.5
#65,000	1	.5
#650,000	1	.5
#70,000	3	1.4
#71,000	1	.5
#75,000	4	1.9
#8,000	1	.5
#80,000	4	1.9
#90,000	4	1.9
#98,000	1	.5
Total	**210**	**100.0**

Table 4.42 indicates the average amount spent in a month according to Nigeria (South West) respondents in which it was observed that 0.5% of the respondents averagely spent ₦2,000, ₦3,000, ₦4,000, ₦8,000, ₦16,000, ₦17,000, ₦22,000, ₦33,000, ₦33,800, ₦49,000, ₦51,000, ₦53,500, ₦57,000, ₦63,500, ₦65,000, ₦71,000, ₦92,000, ₦98,000, ₦130,000, ₦160,000, ₦180,000, ₦200,000, ₦210,000, ₦225,000, ₦240,000, ₦500,000, ₦550,000, ₦630,000, ₦650,000 and ₦1million monthly; 1.0% of the respondents averagely spent ₦6,000, ₦21,000, ₦43,000, ₦55,000 and ₦55,200, 1.4% of the respondents averagely spent ₦5,000 and ₦70,000.

However, 1.9% of the respondents averagely spent ₦35,000, ₦75,000, ₦80,000, and ₦90,000, 2.4% of the respondents averagely spent ₦120,000 and ₦400,000, 2.9% of the respondents averagely spent ₦10,000, ₦25,000, ₦28,000 and ₦100,000, 4.8% of the respondents averagely spent ₦40,000 and ₦150,000, 5.2% of the respondents averagely spent ₦15,000, 5.7% of the respondents averagely spent ₦30,000, 6.2% of the respondents averagely spent ₦20,000 and ₦50,000, 7.1% of the respondents averagely spent ₦40,000, while 10.0% of the respondents averagely spent ₦60,000 monthly. This shows that majority of the respondents in Nigeria (SW) spent ₦60,000 monthly since income depends on waste generated.

Table 4.43. Average Amount Saved in a Month According to Nigeria (SW) Respondent

Average amount saved in a month (Consumption) (₦ = Naira)	Frequency	Percent (%)
₦1,000	1	.5
₦1,500	1	.5
₦10,000	23	11.0
₦100,000	7	3.3
₦12,000	1	.5
₦120,000	2	1.0
₦14,000	5	2.4
₦15,000	22	10.5
₦150,000	3	1.4
₦17,000	1	.5
₦2,000	4	1.9
₦20,000	16	7.6
₦200,000	1	.5
₦21,000	1	.5
₦22,000	1	.5
₦25,000	7	3.3
₦27,000	1	.5
₦28,000	1	.5
₦3,000	2	1.0
₦30,000	17	8.1
₦300,000	3	1.4
₦325,000	1	.5
₦35,000	2	1.0
₦36,800	2	1.0
₦37,500	1	.5
#380,000	1	.5
₦4,000	3	1.4
₦40,000	2	1.0
₦42,000	1	.5
₦46,000	1	.5
₦5,000	33	15.7
₦50,000	16	7.6
₦500	1	.5
₦500,000	2	1.0

Average amount saved in a month (Consumption) (₦ = Naira)	**Frequency**	**Percent (%)**
₦6,000	1	.5
₦60,000	6	2.9
₦600,000	1	.5
₦7,000	2	1.0
₦7,500	3	1.4
₦70,000	4	1.9
₦73,500	1	.5
₦75,000	2	1.0
₦8,000	1	.5
₦80,000	2	1.0
₦9,000	1	.5
Total	210	100.0

The average amount saved in a month by the respondents of Nigeria (SW) as stated in Table 4.46. 0.5% of the respondents saved ₦500, ₦1,000, ₦1,500,₦6,000, ₦8,000, ₦9,000, ₦12,000, ₦21,000, ₦22,000, ₦27,000, ₦28,000, ₦37,500, ₦42,000, ₦46,000 ₦73,000, ₦200,000, ₦325,000, ₦380,000 and ₦600,000 averagely in a month; 1.4% of the respondents saved ₦3,000, ₦7,000, ₦35,000, ₦36,800, ₦40,000, ₦75,000, ₦80,000, ₦120,000, and ₦500,000 averagely in a month; 1.4% of the respondents saved ₦7,500,₦40,000, ₦150,000 and ₦300,000 averagely in a month; 1.9% of the respondents saved ₦2,000 and ₦70,000 averagely in a month; 2.4% of the respondents saved ₦14,000 averagely in a month; 2.9% of the respondents saved ₦60,000 averagely in a month.

However, 3.3% of the respondents saved ₦25,000 and ₦100,000 averagely in a month; 8.1 % of the respondents saved #30,000 averagely in a month; 7.6% of the respondents saved ₦20,000 and ₦50,000 averagely in a month; 10.5% of the respondents saved ₦15,000 averagely in a month; 11.0% of the respondents saved ₦7,500, ₦40,000, ₦150,000 and ₦300,000 averagely in a month; while 15.7% of the respondents saved ₦5,000 averagely in a month; Therefore this indicates that majority of the respondents saved ₦5,000 averagely in a month.

Table 4.44. Challenges Faced in Managing Waste in Nigeria (SW)

What are the challenges you face in managing your waste?	Frequency	Percent (%)
Air Pollution	22	10.5
Flooding and Blockage of dams	1	.5
Lack of Equipment by the Government Agency	42	20.0
No dumpsite	1	.5
Skin Rashes	7	3.3
Sometimes delay which results in breeding of pest and invasion	41	19.5
No Response	96’	45.7
Total	210	100.0

Table 4.44 shows the challenges faced in managing waste in SW-Nigeria in which was observed that 19.5% of the respondents said delay in waste collection by the waste management authority is the challenges faced in managing waste; 20.0% of the respondents said lack of equipment by the government agency is the challenge faced in managing waste, 10.5% of the respondent said air pollution is the challenge faced in managing waste, 3.3% of the respondent said skin rashes are the challenges faced in managing waste, while 0.5% of the respondents said no dumpsite / flooding and blockage of dams are the challenges faced in managing waste in SW-Nigeria. This implies that lack of equipment by the government agency is one of the major challenges faced in waste management in SW-Nigeria. Table 4.48 indicates SW-Nigeria respondents on how many bags of waste generated in their household per week in which it was observed that 45.7% of the respondents said they were generating 1-2 bags per week; 26.7% of the respondents said they were generating 2-4 bags, 11.0% of the respondents said they were generating >4bags per week; while 16.7% of the respondents said they were generating 1 or more drums.

This shows majority of the waste generated in SW-Nigeria are between 1-2 bags. This reveals that Lagos State by the virtue of its huge population (>20 million) is the highest waste generating State in Nigeria according to this research. Table 4.49 shows SW-Nigeria respondents on if waste management helps in reducing the level of pollution in their Area and it was observed that 0.5% of the respondents strongly disagree that waste management helps in reducing the level of pollution in their Area, 5.7% of the respondents disagree that waste management helps in reducing the level of pollution in their Area, 21.4% of the respondents agree that waste management helps in reducing the level of pollution in their Area while 72.4% of the respondents strongly agree that waste management helps in reducing the level of pollution in their Area. This implies that majority of the SW-Nigeria (Southwestern Nigeria) respondents strongly agree that waste management helps in reducing the level of pollution in their Area.

Table 4.45 A&B. SW-Nigeria Respondents on Quantity of Waste Generated in Household per week and if Waste Management helps in Reducing the Level of Pollution in their Area, respectively

How many bags of waste do you generate in your household per week?	Frequency	%
1-2 bag (s)	96	45.7
2-4 bags	56	26.7
>4bags	23	11.0
1 or more drums	35	16.7
Total	210	100.0

Table 4.44 B.

Waste management helps in reducing the level of pollution in my area	Frequency	Percent (%)
Strongly Disagree	1	.5
Disagree	12	5.7
Agree	45	21.4
Strongly Agree	152	72.4
Total	210	100.0

4.1.1 Inferential Statistics

Comparison test was conducted to know the effect of waste-energy on some selected variables. According to the stated hypothesis, which is to test the relationship between the willingness to pay for waste-to-energy as a better options to generator / national grid (DISCOS) and income level in Lagos State. The outcomes of the statistical tests employing correlations and Chi-square are displayed in Table 4.45. This shows that willingness to pay for waste-to-energy as a better option to generator / national grid has no significant effect on income level in Lagos State at p-value < 0.05, and there is negative correlation between the willingness to pay for waste-to-energy (WtE) as a better options to generator/national grid and income level in Lagos State. This implies willingness to pay for WtE as a better options to generator / national grid and income level in Lagos State. According to the stated hypothesis, which is to test the relationship between Location and Availability of Waste (Feedstock) for WtE generation in Lagos State.

It appears that there is a modest positive correlation between location/source of waste and availability of waste for WtE generation in Lagos, as shown in Table 4.46, where a check on location and availability of waste for WtE generation in Lagos State yields an insignificant result at p-value 0.05. The hypothesis is to test the effect of clean energy and environment (i.e. better waste management & energy security / reliability) against Respondents' choice for WtE as a better option for clean energy & environment in Lagos. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.46, in which a check on effect of clean energy and environment against Respondents' choice for WtE as a better option for clean energy and environment in Lagos yield significant result at p-value < 0.05, then it seems to be a negative correlation on effect of clean energy and environment against Respondents' choice for WtE as a better option for clean energy and environment in Lagos State.

Table 4.46. Test Result of Willingness to Pay for WtE as a Better Option to Generator and National Grid (DISCOS) against Income Level in Lagos State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Income level	7	11.620[a]	0.114	-0.195	.122[c]

Key: *significant [a,c]Not Significant

Table 4.47 Test Result of Location and Availability of Waste (Feedstock) for WtE Generation in Lagos State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Preferred location(s) where WtE should be built	8	11.449[a]	0.178	0.042	.687[c]

Key: *significant [a,c]Not Significant

Table 4.48. Test Result of Clean Energy and Environment (i.e. Better Waste Management & Energy Security / Reliability) against Respondents' Choice for WtE as a Better Option for Clean Energy & Environment in Lagos State

Variables	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Would you like these wastes to be used to generate electricity for your household and work?	3	15.374[a]	0.002	-0.305	.014*
Will you support and encourage waste -to- energy project if introduced to save both waste management & electricity problems in your area?	3	12.350[a]	0.006	-0.341	.006*

Key: *significant [a,c]Not Significant

Table 4.49. Test Result Effects of Waste Management Challenges against Health Issues / Pollution in Lagos State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Health issues/pollution	9	42.657[a]	0.000	0.558	.000*

Key: *significant [a,c]Not Significant

According to the stated hypothesis, which is to test the relationship between effects of waste management challenges against health issues/pollution in Lagos State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.48, which determine the effects of waste management challenges on health issues/ pollution in Lagos State yield significant result at p-value < 0.05, then it also illustrates that there is moderate positive correlation between the effects of waste management challenges on health issues / pollution in Lagos State. This demonstrates that waste management challenges have effects on Health issues / pollution in Lagos State.

According to the stated hypothesis, which is to test the relationship between the willingness to pay for WtE as a better option to generator/ national grid and income level in Ogun State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.49.

This shows that willingness to pay for WtE as a better option to generator /national grid has significant effect on income level in Ogun State at p-value < 0.05, and there is negative correlation between the willingness to pay for WtE as a better option to generator/national grid and income level in Ogun State. That is willingness to pay for waste-to-energy as a better option to generator and national grid has nothing to do with income level. According to the stated hypothesis, which is to test the relationship between the willingness to pay for WtE as a better option to generator / national grid (DISCOS) and income level in Osun State. The outcomes of the statistical tests employing correlations and Chi-square are displayed in Table 4.51.

Although there appears to be a weak correlation (however positive) between the willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) and income level in Osun State, a check on willingness to pay for WtE as a better option to generator / national grid and income level in Osun State yields an insignificant result at p-value 0.05. That is, the degree of income has no bearing on one's willingness to pay for waste-to-energy as a superior alternative to generators and the national grid.

Table 4.50. Test Result of willingness to pay for WtE as a better options to generator and national grid (DISCOS) against income level in Ogun State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Income level	7	16.307[a]	0.022	-0.373	.002 *

Key: *significant [a,c]Not Significant

Table 4.51. Test Result of Willingness to Pay for WtE as a Better Option to Generator and National Grid (DISCOS) against Income Level in Osun State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Income level	5	1.787[a]	0.878	0.210	.265 [c]

Key: *significant [a,c]Not Significant

Table 4.52. Test Result of Location and Availability of Waste (Feedstock) for Waste - to- Energy (WtE) generation in Ogun State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Preferred location(s) where WtE should be built	8	7.066[a]	0.530	-0.024	.900[c]

Key: *significant   [a,c]Not Significant

By the stated hypothesis, which is to test the relationship between Location and Availability of Waste (Feedstock) for WtE generation in Ogun State. It was observed that location and availability of waste for WtE generation in Ogun State yield an insignificant result at p-value 0.05, suggesting that there may be a weak negative correlation between location/source of waste and availability of waste for WtE generation in Ogun State. Table 4.51 displays the results of statistical tests using Chi-square and correlations.

According to the stated hypothesis, which is to test the relationship between effects of waste management challenges against health issues/pollution in Ogun State. Table 4.53 displays the results of statistical tests using Chi-square and correlations to determine the effects of waste management challenges on health issues / pollution in Ogun State. It also demonstrates that there is a positive correlation between the effect of waste management challenges on health issues / pollution in Ogun State. The results of the tests were insignificant at p-values 0.05. This reveals that waste management challenges has no effect on Health issues / pollution in Ogun State.

By the stated hypothesis, which is to test the relationship between the willingness to pay for WtE as a better option to generator / national grid (DISCOS) and income level in Ogun State. The outcomes of the statistical tests employing correlations and Chi-square as displayed in Table 4.53, indicated a negative link between the readiness to pay for WtE as a superior option to generator / national grid (DISCOS) and income level in Ekiti State, as shown by the fact that WtE had an insignificant influence on income level in Ekiti State at p-value 0.05. This shows that willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) has no effect on income level.

Table 4.53. Test Result Effects of Waste Management Challenges against Health Issues / Pollution in Ogun State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Health issues/pollution	6	8.402[a]	0.210	0.182	.335[c]

Key: *significant [a,c]Not Significant

Table 4.54. Test Result of Willingness to Pay for WtE as a Better Options to Generator and National Grid (DISCOS) against Income Level in Ekiti State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Income level	7	9.310[a]	0.231	-0.294	.115 [c]

Key: *significant [a,c]Not Significant

Table 4.55. Test Result of Location and Availability of Waste (Feedstock) for Waste -to-Energy (WtE) Generation in Ekiti State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Preferred location (s) where WtE should be built	8	7.644[a]	0.469	0.157	.407[c]

Key: *significant [a,c]Not Significant

According to the stated hypothesis, which is to test the relationship between Location and Availability of Waste (Feedstock) for WtE generation in Ekiti State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.59, in which a check on location and availability of waste for WtE generation in Ekiti State yield an insignificant result at p-value < 0.05, then it seems to be a weak positive correlation between location / source of waste and availability of waste for WtE generation in Ekiti State.

According to the stated hypothesis, which is to test the relationship between effects of waste management challenges against health issues/pollution in Ekiti State. Table 4.60 displays the results of statistical tests using Chi-square and correlations to determine the effects of waste management issues on health problems and pollution in the state of Ekiti. The tests are significant when the p-value is less than 0.05, and the results also demonstrate a moderately positive correlation between the effects of waste management issues on health problems and pollution in the state. This demonstrates how pollution and health problems in Ekiti State are impacted by problems with waste management.

By the stated hypothesis, which is to test the relationship between the willingness to pay for WtE as a better option to generator/ national grid (DISCOS) and income level in Osun State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.61. This shows that willingness to pay for WtE as a better option to generator / national grid (DISCOS) yield an insignificant effect on income level in Osun State at p-value < 0.05, and there is weak positive correlation between the willingness to pay for WtE as a better options to generator / national grid (DISCOS) and income level in Osun State.

Table 4.56. Test Result Effect of Waste Management challenges against Health Issues / Pollution in Ekiti State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Health Issues / Pollution	9	11.847[a]	0.222	0.438	.016*

Key: *significant [a,c]Not Significant

Table 4.57. Test Result of Willingness to Pay for Waste-to-Energy as a Better Options to Generator and National Grid (DISCOS) against Income Level in Osun State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Income level	7	4.138[a]	0.764	0.022	.909 [c]

Key: *significant [a,c]Not Significant

Table 4.58. Test Result of Location and Availability of Waste (Feedstock) for Waste - to- Energy (WtE) Generation in Osun State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Preferred location(s) where WtE should be built	8	5.993[a]	0.648	0.163	.391[c]

Key: *significant [a,c]Not Significant

By the stated hypothesis, which is to test the relationship between Location and Availability of Waste (Feedstock) for WtE generation in Osun State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.57, in which a check on location and availability of waste for WtE generation in Osun State yield an insignificant result at p-value < 0.05, then it seems to be a weak positive correlation between location/source of waste and availability of waste for WtE generation in Osun State.

According to the stated hypothesis, which is to test the relationship between effects of waste management challenges against health issues/pollution Osun State. Table 4.58 displays the findings of statistical tests using Chi-square and correlations to determine the impact of waste management issues on health problems and pollution in Osun State. Significant results are shown at p-values less than 0.05, and the table also reveals a moderately positive correlation between the impact of waste management issues on health problems and pollution in Osun State. This reveals that waste management challenges have effects on Health issues / pollution in Osun State.

By the stated hypothesis, which is to test the relationship between the willingness to pay for waste-to-energy as a better option to generator/ national grid (DISCOS) and income level in Oyo State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.64. This shows that willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) yield an insignificant effect on income level in Oyo State at p-value < 0.05, and there is negative correlation between the willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) and income level in Oyo State.

Table 4.59. Test Result Effect of Waste Management challenges against Health Issues / Pollution in Osun State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Health issues/pollution	9	17.192[a]	0.046	0.500	.005*

Key: *significant   [a,c]Not Significant

Table 4.60. Test Result of Willingness to Pay for Waste-to-Energy as a Better Options to Generator and National Grid (DISCOS) against Income level in Oyo State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Income level	6	5.172[a]	0.522	-0.276	.139 [c]

Key: *significant [a,c]Not Significant

Table 4.61. Test Result of Location and Availability of Waste (Feedstock) for Waste -to-Energy (WtE) Generation in Oyo State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Preferred location(s) where WtE should be built	6	5.987[a]	0.425	-0.229	.223[c]

Key: *significant [a,c]Not Significant

According to the stated hypothesis, which is to test the relationship between Location and Availability of Waste (Feedstock) for WtE generation in Oyo State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.60, in which a check on location and availability of waste for WtE generation in Oyo State yield an insignificant result at p-value < 0.05, and it seems to be a weak negative correlation between location / source of waste and availability of waste for WtE generation in Oyo State. According to the stated hypothesis, which is to test the relationship between effects of waste management challenges against health issues/pollution in Oyo State. Table 4.61 displays the results of statistical tests using Chi-square and correlations to determine the effects of waste management challenges on health issues / pollution in Oyo State. It also reveals that there is a weak positive correlation between the consequence of waste management challenges on health issues / pollution in Oyo State. Results of these tests were insignificant at p-values <0.05. This reveals that waste management challenges have no effect on Health Issues / pollution in Oyo State.

By the stated hypothesis, which is to test the relationship between the willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) and income level in Ondo State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.62. This shows that willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) yield an insignificant effect on income level in Ondo State at p-value < 0.05, and there is weak negative correlation between the willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) and income level in Ondo State.

Table 4.62. Test Result Effect of Waste Management Challenges against Health Issues / Pollution in Oyo State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Health issues/pollution	9	10.353[a]	0.323	0.324	.080[c]

Key: *significant [a,c]Not Significant

Table 4.63. Test Result of willingness to pay for Waste-to-Energy as a Better Options to Generator and National Grid (DISCOS) against Income Level in Ondo State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Income level	5	7.973[a]	0.158	-0.068	.741 [c]

Key: *significant [a,c]Not Significant

Table 4.64. Test Result of Location and Availability of Waste (Feedstock) for Waste -to-Energy (WtE) Generation in Ondo State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Preferred location(s) where WtE should be built	6	7.213[a]	0.302	-0.012	.954[c]

Key: *significant [a,c]Not Significant

According to the stated hypothesis, which is to test the relationship between Location and Availability of Waste (Feedstock) for WtE generation in Ondo State. The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.63, in which a check on location and availability of waste for WtE generation in Ondo State yield an insignificant result at p-value < 0.05, and it seems to be a weak negative correlation between location/source of waste and availability of waste for WtE generation in Ondo State.

According to the stated hypothesis, which is to test the relationship between effects of waste management challenges against health issues/pollution in Ondo State. Table 4.64 displays the results of statistical tests using Chi-square and correlations to determine the impact of waste management issues on health problems and pollution in Ondo State. It also demonstrates that there is a moderately positive correlation between the impact of waste management issues on health problems and pollution in Ondo State. This reveals that waste management challenges have effects on Health issues / pollution in Ondo State.

Table 4.65. Test Result Effect of Waste Management challenges against Health Issues / Pollution in Ondo State

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Health issues/pollution	6	17.603[a]	0.007	0.618	.001*

Key: *significant [a,c]Not Significant

Table 4.66. Test Result of willingness to pay for Waste-to-Energy as a Better Options to Generator & National Grid (DISCOS) Against Income Level in Nigeria (SW)

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Income Level	7	11.296[a]	0.126	-0.115	.097 [c]

Key: *significant [a,c]Not Significant

By the stated hypothesis, which is to test the relationship between the willingness to pay for waste-to-energy as a better option to generator/ national grid (DISCOS) and income level in Nigeria (SW). The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.65. This shows that willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) yield an insignificant effects on income level in Nigeria (South West) at p-value < 0.05, and there is weak negative correlation between the willingness to pay for waste-to-energy as a better option to generator / national grid (DISCOS) and income level in Nigeria (SW). According to the stated hypothesis, which is to test the relationship between Location and Availability of Waste (Feedstock) for waste -to- energy (WtE) generation in Nigeria (SW). The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.66, in which a check on location and availability of waste for WtE generation in Nigeria (SW) yield an insignificant result at p-value < 0.05, and there is a weak positive correlation between location / source of waste and availability of waste for waste-to-energy generation in Nigeria (SW).

The hypothesis is to test the effects of clean energy and environment (i.e. better waste management & energy security/reliability) against Respondents' choice for WtE as a better option for clean energy & environment in Nigeria (SW). The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.67. in which a check on the effects of clean energy and environment (i.e. better waste management & energy security / reliability) against Respondents' choice for WtE as a better option for clean energy and environment in Nigeria (South West) yield significant result at p-value < 0.05, then it seems to be a negative correlation on the effects of clean energy and environment (i.e. better waste management & energy security / reliability) against Respondents' choice for WtE as a better option for clean energy and environment in Nigeria (South West).

Table 4.67. Test Result of Location and Availability of Waste (Feedstock) for WtE generation in Nigeria (SW)

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Preferred location(s) where WtE should be built	8	16.961[a]	0.301	0.028	.997[c]

Key: *significant [a,c]Not Significant

Table 4.68. Test Result of Clean Energy and Environment (i.e. Better Waste Management & Energy Security / Reliability) against Respondents' Choice for WtE as a Better Option for Clean Energy & Environment in Nigeria (SW)

Variables	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Would you like these wastes to be used to generate electricity for your household and work?	3	42.811[a]	0.000	-0.202	.000*
Will you support and encourage waste -to- energy project if introduced to save both waste management & electricity problems in your area?	3	49.861[a]	0.000	-0.263	.000*

Key: *significant [a,c]Not Significant

Table 4.69. Test Result Effect of Waste Management Challenges against Health Issues / Pollution in Nigeria (SW)

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Health issues/pollution	9	65.628[a]	0.000	0.443	.000*

Key: *significant [a,c]Not Significant

According to the stated hypothesis, which is to test the relationship between effects of waste management challenges against health issues / pollution in SW-Nigeria. Table 4.68 displays the results of statistical tests using Chi-square and correlations to determine the effects of waste management issues on health problems and pollution in Nigeria (SW). The tests are significant when the p-value is less than 0.05, and the results also reveal a moderately positive correlation between the impact of waste management issues on health problems and pollution in SW-Nigeria. This reveals that waste management challenges have effects on Health issues / pollution in Nigeria (SW).

By the stated hypothesis, which is to test the relationship between the willingness to pay for waste-to-energy as a better option to generator / national grid and income level in Ghana (Accra, Legon and Pantang). The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.69. This shows that willingness to pay for waste-to-energy as a better option to generator/ national grid yield an insignificant effect on income level in Ghana (Accra, Legon and Pantang) at p-value < 0.05, and there is weak negative correlation between the willingness to pay for waste-to-energy as a better option to generator/national grid and income level in Ghana (Accra, Legon and Pantang). This shows that willingness to pay for waste-to-energy as a better option to generator / national grid has nothing to do with income level.

By stated hypothesis, which is to test the relationship between Location and Availability of Waste (Feedstock) for waste -to- energy (WtE) generation Ghana (Accra, Legon and Pantang). The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.70, in which and it was observed that location and availability of waste for waste-to-energy (WtE) generation in Ghana (Accra, Legon and Pantang) yield significant result at p-value < 0.05, with negative correlation between location/source of waste and availability of waste for waste-to-energy (WtE) generation Ghana (Accra, Legon and Pantang).

Table 4.70. Test Result of willingness to pay for Waste-to-Energy as a better options to Generator and National Grid against income level in Ghana (Accra, Legon and Pantang)

Variable	Chi-Square			Correlations	
	Df	**Value**	**Pvalue**	**Value**	**Pvalue**
Income level	4	1.775[a]	0.777	-0.45	.785 [c]

Key: *significant [a,c]Not Significant

Table 4.71. Test Result of Location and Availability of Waste (Feedstock) for Waste - to- Energy (WtE) Generation in Ghana (Accra, Legon and Pantang)

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Preferred location(s) where WtE should be built	8	13.906[a]	0.044	-0.432	.005*

Key: *significant [a,c]Not Significant

Table 4.72. Test Result of Clean Energy and Environment (i.e. Better Waste Management & Energy Security / Reliability) against Respondents' choice for Waste-to-Energy as a Better Option for Clean Energy & Environment in Ghana (Accra, Legon and Pantang)

Variables	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Would you like these wastes to be used to generate electricity for your household and work?	3	1.581[a]	0.664	-0.137	.401[c]
Will you support and encourage waste -to- energy project if introduced to save both waste management & electricity problems in your area?	3	1.581[a]	0.664	-0.137	.401[c]

Key: *significant [a,c]Not Significant

The hypothesis is to test effect of clean energy and environment (i.e. better waste management & energy security/reliability) against Respondents' choice for WtE as a better option for clean energy & environment in Ghana (Accra, Legon and Pantang). The outcomes of the statistical analyses utilizing Chi-square and correlations are shown in Table 4.71, in which a check on the effects of clean energy and environment (i.e. better waste management & energy security / reliability) against Respondents' choice for WtE as a better option for clean energy & environment in Ghana (Accra, Legon and Pantang) yield an insignificant result at p-value < 0.05, then it seems to be a negative correlation on the effects of clean energy and environment (i.e. better waste management & energy security/reliability) against Respondents' choice for WtE as a better option for clean energy and environment in Ghana (Accra, Legon and Pantang).

According to the stated hypothesis, which is to test the relationship between the effects of waste management challenges against health issues / pollution in Ghana (Accra, Legon and Pantang). Table 4.72 displays the results of statistical tests using Chi-square and correlations to determine the effects of waste management issues on health problems and pollution in Ghana (Accra, Legon, and Pantang). The tests are significant when the p-value is less than 0.05, and the table also reveals a moderately positive correlation between the effects of waste management issues on health problems and pollution in Ghana (Accra, Legon and Pantang). This reveals that waste management challenges have effects on Health issues / pollution in Ghana (Accra, Legon and Pantang).

Table 4.73. Test Result Effects of Waste Management Challenges against Health Issues / Pollution in Ghana (Accra, Legon and Pantang)

Variable	Chi-Square			Correlations	
	Df	Value	Pvalue	Value	Pvalue
Health issues/pollution	9	33.083[a]	0.000	0.549	.000*

Key: *significant [a,c]Not Significant

4.2 Cost–Benefit Analysis of Waste-to-Energy Recovery Generation Technology in Nigeria

Cost-Benefit-Analysis (CBA) is the process whereby a plant or project is assessed for its social and welfare benefits in addition to the consideration of financial return on investment e.g. this might take into account the environmental impact of an industrial plant or convenience for users of a new project. A major challenge is finding the way of quantifying net social costs and benefits.

Table 4.74. Cost-Benefit Analysis of ReGen in Nigeria

With the WtE plant	Without the WtE plant
By burning 80% of the waste produced, the amount of waste dumped in landfills is cut by 80%.	Increased emphasis on hygienic land filling and composting. Composting and biomethanation, however, are laborious procedures that need a lot more acreage than WtE plants.
Increased air pollution by emissions from the WtE plant.	Low labor expenses make the expense of decomposition and/or land filling cheap.
According to the WHO, building a secure WtE facility might prevent up to 22 illnesses.	There might be a greater focus on reusing. Due to the need to change the attitudes of the populace, who are not accustomed to recycling, it could not be practicable in the same amount of time as a WtE plant can be constructed.
The "bottom-ash" component of MSW makes up around 20% of its gravity and, following processing, may be utilised to build roads, make concrete blocks, fill dirt, and cover landfills on a regular and permanent basis.	WtE plants' increasing air pollution might not occur.
0.06 km2 of land would be required for a WtE infrastructure.	Usage of 1.7 km2 for unhygienic land filling continues.

With the WtE plant	Without the WtE plant
To help with part of the electrical requirements, particularly at peak times, provide additional energy sources.	Use of non-renewable energy resources like natural gas should be increased to close the gap in optimum energy generation.
Minimizes the stench and air pollution that unclean landfills discharge.	To address the rising health hazards from air pollution and water pollution from landfills, the authorities will need to raise health care prices.
Reduced water contamination potential if WtE plant is constructed appropriately.	Utilisation of other non-renewable energy resources, such as solar PV and wind, might be boosted, nevertheless they are less dependable than WtE.
reduction of MSW transportation-related expenses and carbon.	WtE facilities may not always result in less trash being created, but even without one, the government can still develop regulations and education programs that encourage people to produce less garbage.

4.2.1 Calculating Cost-Benefit Analysis

In order to evaluate the net cost of Waste-to-Energy recovery generation (ReGen) in comparison to continuing the current land filling of MSW, a *Costs-Benefits analysis* of the two waste management methods will be evaluated.

Where;

Costs are the total costs related with a given method;

Benefits are the total benefits related with a given method.

<u>Cost:</u> the costs include total cost accrued to a waste management method including the economic and environment.

$$Cost_T = CT_{Construction} + CT_{Land} + CT_{O\&M} + CT_{Fuel} + CT_{Environmental}$$

$$Cost_L = CL_{Land} + CL_{Collection\ and\ Transportation} + CL_{Operating\ and\ Labour} + CL_{Environmental}$$

……………………………………………4.1

Where:

$Cost_T$ is the total cost related with the Re-Gen WtE technology;

$Cost_L$ is the total cost related with landfill;

$CT_{Construction}$ is the cost related with the construction of the Re-Gen WtE technology;

CT_{Land} is the cost related with acquiring the land that will be used for the Re-Gen WtE technology and necessary facilities;

$CT_{O\&M}$ is the cost related with operating and managing the Re-Gen WtE technology

CT_{Fuel} is the fuel cost related with operating the Re-Gen WtE technology and necessary facilities;

$CT_{Environmental}$ is the monetary cost related with emissions and other environmental effects of the Re-Gen WtE technology;

CL_{Land} is the cost related with acquiring the land that will be used for one landfill site;

CL_{Labour} is the labour cost related with operating one comparable landfill

$CL_{Collection\ and\ Transportation}$ is the collection and Transportation cost related with operating one comparable landfill

$CL_{Operation\ and\ Labour}$ is the other operational and labour costs related with operating one comparable landfill

$CL_{Environmental}$ is the monetary cost related with emissions and other environmental effects of one landfill project;

Benefit:

We model the benefits of the Re-Gen WtE technology as following:

$Benefit_T = BT_{Energy} + BT_{Environmental}$ 4.2

Where

$Benefit_T$ is the total benefit related with the Re-Gen WtE technology

BT_{Energy} is the monetary benefit (revenue) related with selling electricity produced;

$BT_{Environmental}$ is the amount of emissions mitigated through switching to the Re-Gen WtE technology;

Net (Costs-Benefits)

$$Net(cost)_{ReGEnWtE} = Cost_T - Benefit_T$$

$Net(cost)_{Landfill} = Cost_L$ 4.3

*In this comparison, note that the Re-Gen WtE technology site has the capacity to process higher Tons of waste Per Day: 24 (TPD) than an average landfill site (given the same amount of land usage).

Time frame and Discount Rate:

Although the 25 years is the generally assumed average lifespan for WtE plants, but 30 years is the lifespan of ReGen (a plus regarding time frame). For discount rates, we use 14% per year as indicated by the current price of the Nigeria's government saving bond for long term investment. Other data collected for this study will be cited accordingly.

ReGen WtE Technology

Construction Costs

The construction cost is estimated at 5.5million dollars for the prototype that processes 600-1000 kg of waste per hour (>20 tonnes daily).

Land Costs

The proposed site for the WtE technology is assumed to be government-owned and this eliminates land cost for any WtE technology. But if it were private owned, the plant will require three plots of land at 1000 US$ per plot which is over 30 times smaller than a regular landfill.

Operation and Maintenance

The operation and maintenance cost function for the WtE technology is 125,000 USD$ per annum, for 30 years at 14% discount rate it will be

$$CT_{O\&M} = \sum_{t=1}^{30} \frac{\$0.125\, million}{(1+14\%)^t} = \$3.308\, million \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 4.4$$

Fuel Costs

Because the heating value of the trash produced is less than 8,000 kJ/kg, researchers are considering that Fuel Costs are minimal. Hence, additional fuel cost of 1.50 per ton of waste processed will be included.

Environmental Costs

The composition of the typical state MSW and environmental cost for each kind of trash, as well as the projected tonnes per day (TPD) capacity of the WtE technology, will be used to determine the environmental cost on a dollar cost per day, dollar cost per year, and dollar cost per ton of MSW. The costs associated with collection and disposal are excluded from environmental costs. The cost buildup over a 30-year period will be calculated utilizing the calculation below. The average Environmental Cost for the appropriate WtE technology and landfill will be sourced from[1] as adopted from (Azodo, 2019).

$$CT_{Environmental} = \sum_{t=1}^{n} \frac{Total\ Environmental\ Cost\ _{\$/year}}{(1+i_d\%)^t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 4.5$$

Energy Benefits

The value of energy that the WtE technology would generate in dollar per day and per year will be estimated using the capacity of the plant. Considering the tonnes per day (TPD) incineration capacity planned. The following calculation will be used to calculate the energy benefit over a 30-year period while maintaining the price of electricity constant.

$$BT_{Energy} = \sum_{t=1}^{n} \frac{Total\ Energy\ benefits_{\$/year}}{(1+i_d\%)^t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 4.6$$

[1] CIWMB, *Disposal cost fee study, final report*, p.6-54.

Where

$Total\ Energy\ benefits_{\$/year} = Total\ Energy\ Generated\ Per\ annum * Energy\ Price\ in\ USD$

Environmental Benefits

To estimate the environmental benefits of the WtE technology in dollars per day or per year, we will adopt the environmental benefit function of (Azodo, 2019) in Nigeria, It was said that whenever MSW is burned, it may substitute 0.25 tons of coal in the production of energy. Hence, the environmental benefits accrued will be 50% of the environmental cost of the incinerator.

In a 30-year span, the benefit accumulated will be estimated using the equation below.

$$BT_{Environmental} = \sum_{t=1}^{n} \frac{Total\ Environmental\ benefits_{\$/year}}{(1+i_d\%)^t} \quad \ldots\ldots 4.7$$

Where

$$Total\ Environmental\ benefits_{\$/year} = Amount\ of\ CO_2\ emission\ reduced\ per\ year * Environmental\ Cost$$

<u>Landfill</u>

Since the average incinerator takes 4.4 times less land space per ton of waste processed, the landfill is estimated to take (30 times more) plots of land.

Land Costs

The proposed site for the appropriate WtE technology is assumed to be government-owned and this eliminates land cost for landfill.

Labour Costs

The preponderance of the landfill's labor expenses are related to gathering and transporting waste. Due to the lack of data, we can only assume that annual labor expenses will be 5% of the capital expenditures, disregarding gathering and transit, which were mentioned in the below.

Collection and Transportation Costs

The collection and transportation cost of MSW in Nigeria will be obtained from (Azodo, 2019) which was estimated to be USD$ 19.25 per ton.

Other Operating Costs

Other operating costs will be estimated as 3% of Labour cost

Environmental Costs

Environmental cost of the landfill site was estimated using the same formula and data used in estimating the environmental cost of the appropriate WtE plant above.

4.2.2 ReGen Container Power Plant Waste-to-Energy Recovery Generation Technology

4.2.2.1 The ReGen Technology

The choice and scale of ReGen technology selection or consideration factors for waste-to-energy development in Nigeria are it's environ – socioeconomic benefits, investment risk minimization and financial returns maximization. ReGen employs the standard steam cycle generating electrical self-operating facility, with the aid of the Rankine Cycle technology for steam turbine / boiler burning. Both commercial and household settings struggle with waste. Owing to diesel-fueled generator sets, remote power generation is expensive. The net 332 KW ERK®-ReGen off / on - Grid power supply container power plant at these regions optimizes waste management and decreases electricity costs with a strong priority on energy assurance and stability. Specified parts assembled into several containers allow for high-quality, hassle-free shipping, and quick installation. Both biomass and waste materials were recognized as necessary byproducts of civilisation and are widely distributed across the research region. Since substantial amounts of domestic and industrial activities take place in the study area, a major challenge of the future is to understand how to manage large quantities of waste sustainably.

Therefore, waste sources, their compositions and available waste-to-energy-technology options were researched. An approach has been to minimize the amount of waste produced and to recycle larger fractions of biomass and waste-materials. Renewable energy recovery generation (ReGen) from waste can solve two problems at once; first is treating non-recyclable and non-reusable amounts of waste; and second is generating a significant (decentralized) amount of energy which can be included in the energy-production mix in order to satisfy customer's needs while keeping costs low. Interaction between waste management solutions and energy production technologies can vary significantly, depending on multiple-factors. Thus, the ReGen container power plant design is hinged on the Environment – Economic – Social (EES) dimension.

ReGen is autonomous of changing fossil fuel costs, which translates to energy autonomy with dependable base load supply and the potential for peak demand hybridized to concurrently address the issues of waste, pollution, and power generation. By using alternative fuels to diesel, CO_2 emissions are reduced, and groundwater contamination and marine pollution are prevented via reusing or sustainable thermal waste disposal. The well-known, user-friendly ReGen Plug and Play technology speeds up installation and makes it possible to move to new locations.

4.2.2.2 Capital Cost of ReGen Technology

The initial cost, layout and preparation costs, and transportation costs are included in the ReGen plant's operating cost, installation of the equipment and attendant overheads.

4.2.2.3 ReGen Generation Cost

The ReGen generation cost comprises the cost of one unit of electricity generated from the plant of which the estimation was from equations 4.8 and 4.9 (Newman et al, 2000).

$$GC = (100*APC) / E \qquad \ldots\ldots\ldots\ldots 4.8$$

$$E = 8760*CF*C*1000 \qquad \ldots\ldots\ldots\ldots 4.9$$

Where E is the anticipated output of the generating plant for a year as determined by equation 4b and GC ($/kWh) is the generating cost, APC ($per annum) is the annual plant cost. While CF is the ReGen container power plant's capacity factor, C (KW) is its actual output.

4.2.2.4 Cost Analysis for ReGen Technology

The cost analysis summary for ReGen technology is presented in Table 4.2.2.4. The generation cost for ReGen electricity is $0.71/kWh as shown in Table 4.2.2.4.

Table 4.75. Cost Analysis of ReGen Technology

S/N	ITEMS	DESCRIPTION
1.	ReGen Plant Capacity	2.967MW
2.	ReGen Capital Cost (P)	$3.308 million
3.	ReGen Unit Capital Cost	$0.1103 million
4.	Fixed Duration (Lifespan)	30 years
5.	Annual Fixed Charge	$0.1103 million
6.	Fuel Cost	NIL
7.	Operating Labour, Supplies & Maintenance Costs	$0.0125 million
8.	Annual ReGen Plant Cost	$0.1228 million
9.	Capacity Factor	0.671
10.	Energy Output	17398761.6kWh
11.	Generating Cost	0.71/kWh

Calculations for ReGen Plant are as follow;

Annual Fixed Cost (AFC) = P / Duration = $3.308 million / 30 years = $0.1103 million

Annual Operating Cost (AOC @90% off by Self Operation) = 0.125*0.1 = $0.0125 million

Annual Plant Cost (APC) = AFC + AOC = $0.1103 + $0.0125 = $0.1228 million

Capacity Factor = Net Electric Output / Gross Electric Output = 332KW / 495KW = 0.671

Energy Output (E) = 8760*CF*C*1000 = 8760*0.671*2.967*1000 = 17398761.6kWh

Generating Cost (GC) = (100*APC) / E = (100*122800) / 17398761.6 = $0.71/kWh

Total Annual Cost (TAC) = (15%*P) + AOC = (0.15*3.308) + 0.0125 = $0.509 million

Total Annual Operating Cost (TAOC) = Duration*AOC = 30*0.0125 = $0.375 million

Net Worth = Capital Investment (P) + TAOC = 3.308 + 0.375 = $3.683 million … 4.10

4.2.2.5 ReGen versus Diesel Generator: Economic Evaluation of Alternatives

Since diesel generator is the common off-grid alternative to our unreliable electricity supply from the national grid, so, utilizing the yearly cost technique and the Present Worth method, ReGen container generation facility was contrasted with the diesel generator choices. All costs are translated into equal yearly amounts using the annual cost approach. With the same constant charge rate and assessment period, the annual cost of the alternatives were estimated.

The amount that, if invested at the project's outset, would give an annual return on investment equal to the cost each year is known as the Present Worth. As a result, determining the present value involves using the accompanying guidelines to determine the present value of various options;

1 The same period of analysis and the same time base are used to estimate the present worth irrespective of both having a common life and the same initiating year or not.

2. The present worth is calculated with the same interest rate for the different alternatives plans.

3. The best plan is the one with the least present worth since it reflects the least overall expense. The present value of the various alternate plans is calculated using Equation 4d

Total Annual Costs (TAC) = [r+{r / (1+r) ^r – 1} + {t+ i}]*P + AOC …………4.11

Present Worth = TAC / [r / {1 – (1 + r) ^ - n] = [P + (t +i)*P + AOC] / [r / {1 – (1+r) ^ - n] ……………………………………………………………………………………..4. 12

Where P is the Capital Investment, r is the Interest Rate, t is the Tax Rate on Capital Investment and AOC is the Annual Operating Cost. The result of the Economic Comparison between the ReGen plant and Diesel Generators alternatives is shown clearly that for a 30 year period, it is more economical to use the ReGen plant over the diesel generators.

Calculations for the alternative Diesel Generators are as follow;

Annual Fuel Cost (AFC) =25.1gallons*4litres*24hours*365days*$0.5 =$439752 =$0.44 million ………………………………………………………………………. 4.13

Total Fuel Cost (TFC) for 30 years = Duration*AFC = 30*0.44 = $13.193 million

Annual Maintenance Cost (AMC) = $5*350KW*12months = $21000 = $0.021 million

Total Annual Maintenance Cost (TAMC) = Duration*AMC = 30*0.021 = $0.630 million

Annual Operating Cost (AOC) = AMC + AFC = 0.021 + 0.630 = $0.461 million

Total Annual Operating Cost (TAOC) for 30yrs = Duration*AOC = 30*0.461 = $13.823 million ………………………………………………………………………. 4.14

Capital Investment or Purchase Cost (P) = No of Gen.*Unit Cost = 10*$82000 = $0.820 million

Net Worth = P + TAOC = 0.820 + 13.823 = $13.823 million

Calculating the Present Worth for ReGen Plant and Diesel Generators we have;

$$Present\ Worth(ReGen) = \frac{(t+i)P + AOC}{r\ /\ [\ 1-(1+r)^{-n}} = \frac{TAC}{r\ /\ [\ 1-(1+r)^{-n}}$$

$$Present\ Worth = \frac{(0.05 + 0.1)3.308 + 0.0125}{0.1\ /\ [\ 1 - (1.1)^{-30}} = \frac{0.496 + 0.125}{0.1\ /\ [\ 1 - (0.05731)]}$$

$$Present\ Worth = \frac{0.509}{0.1\ /\ [\ 0.94269]} = \frac{0.509}{0.1061}$$

Present Worth (ReGen) = $4.797 million

$$Present\ Worth(Diesel\ Gen.) = \frac{(t + i)P + AOC}{r\ /\ [\ 1 - (1 + r)^{-n}} = \frac{TAC}{r\ /\ [\ 1 - (1 + r)^{-n}}$$

$$Present\ Worth = \frac{(0.05 + 0.1)0.820 + 0.461}{0.1\ /\ [\ 1 - (1.1)^{-30}} = \frac{0.123 + 0.461}{0.1\ /\ [\ 1 - (0.05731)]}$$

$$Present\ Worth = \frac{0.584}{0.1\ /\ [\ 0.94269]} = \frac{0.584}{0.1061}$$

Present Worth (Diesel Gen.) = $5.504 million ………………. 4.16

Table 4.76. Economic Comparison of ReGen Plant and Diesel Generators

S/N	ITEM	ReGen	Diesel Generators
1.	Capital Investment (P)	$3.308 million	$0.820 million
2.	Interest Rate (i)	10%	10%
3.	Number of Years (n)	30	30
4.	Tax Rate on Capital (t)	5%	5%
5.	Annual Operating Cost (AOC)	$0.0125 million	$0.461 million
6.	Total Annual Cost (TAC) = (15%*P) + AOC	$0.509 million	$0.584 million
7.	**Present Worth (PW)**	**$4.797 million**	**$5.504 million**
8.	Total Annual Operating Cost = 30yrs*AOC	$0.375 million	$13.830 million
9.	Net Worth = P + TAOC	$3.683 million	$13.823 million

4.2.2.6 ReGen Technical Details

As per popular demand from this research survey (68.6%), ReGen container power plant will be located on (or close to) the dumpsite(s) in the capital cities that harbour lots of industries, commercial and organized residential facilities that require "reliable" electricity for socioeconomic activities. The ReGen plant will consist of the following main facilities namely;

1. Fuel Preparation Unit – using municipal solid waste (MSW) as fuel
2, Combustion System
3. Auxiliary Equipment
4. Heat Recovery Boiler
5. Flue Gas Cleaning Unit
6. Power Block
7. Control Room
8. Workshop
9. The Electrical Power Output can also be supplied to potential customers (industrial, commercial and residential) through existing DISCOS distribution system.
10. Waste (MSW) Feed will be approximately 1 tonne per hour equaling 24 tonnes per day and 24*365 = 8760 tonnes per year, which totals 70,080 tonnes in the maximum 8 year payback period.

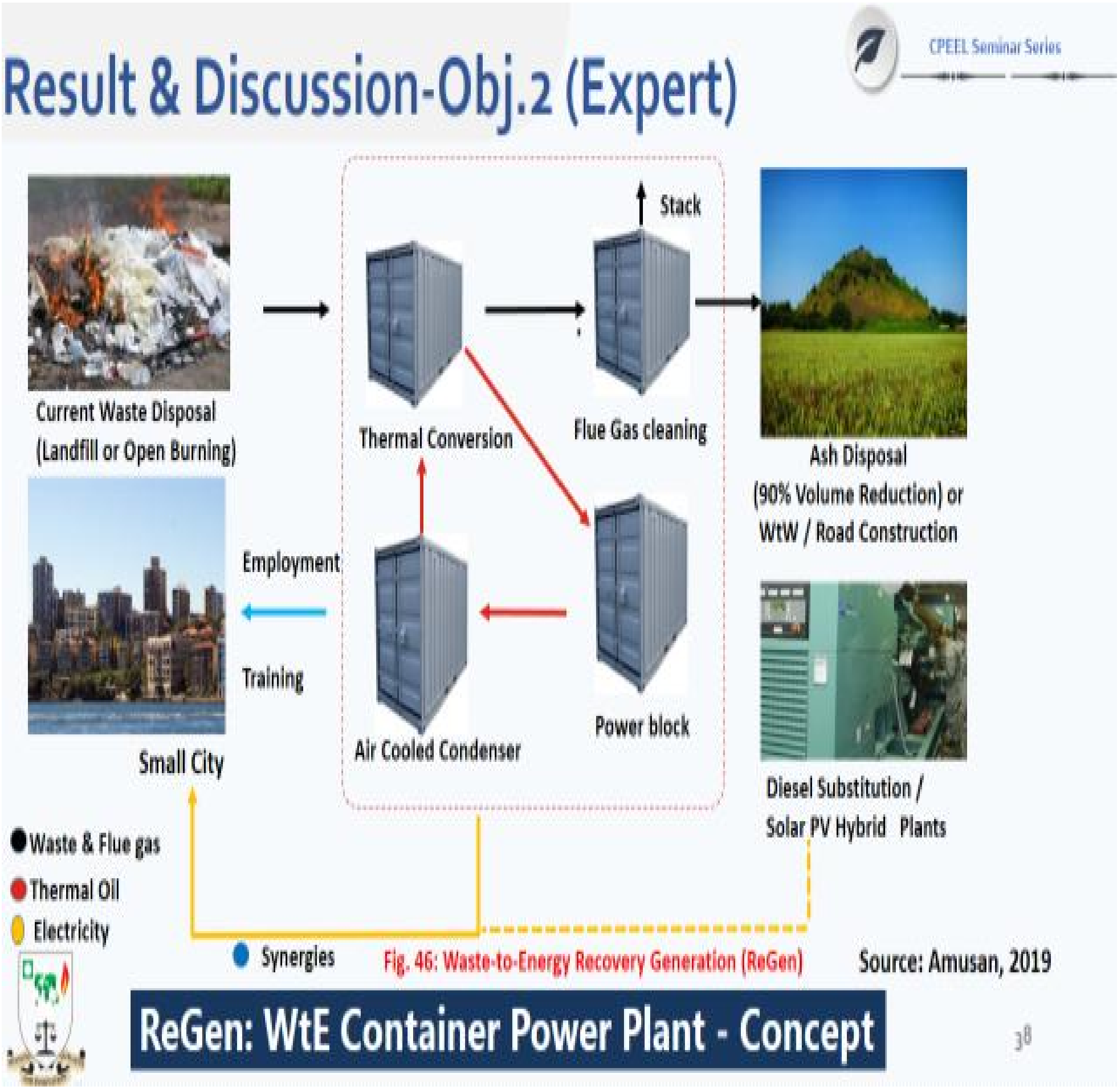


Figure 4.3. ReGen 332KW Container Power Plant Concept (Source: Author's Compilation)

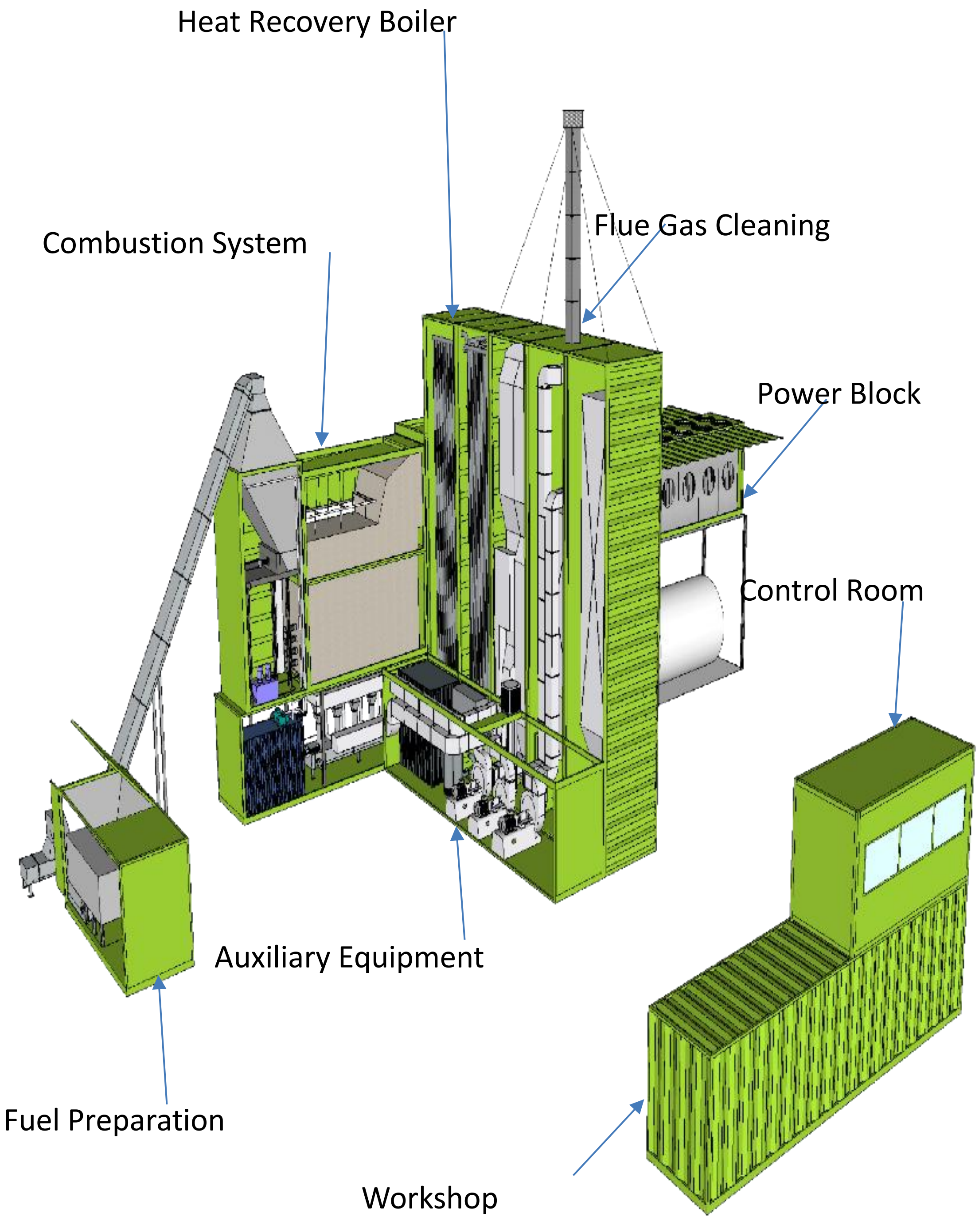


Figure 4.4. ReGen Container Power Plant Arrangement (Source: Author's Compilation)

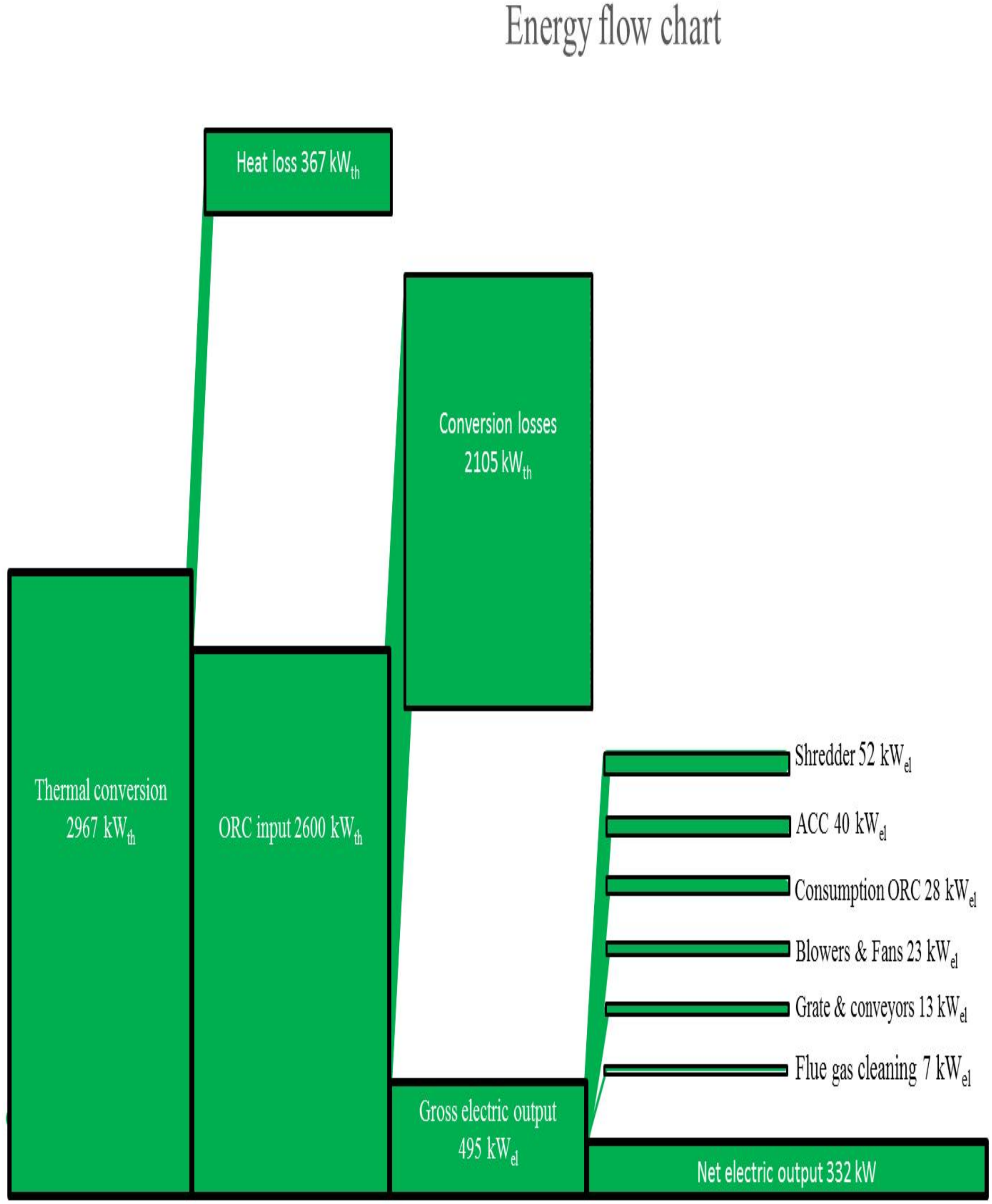


Figure 4.5. ReGen Container Power Plant Energy Balance (Source: Author's Compilation)

Table 4.77. ReGen Performance & Return-On-Investment (ROI)

WtE ReGen Performance Characteristics							
1. Delivery = 8 months (<1 year)							
2. Fuel Throughput = 980Kg/hour							
3. Fuel = Biomass to MSW							
4. Operating Pressure = 5 bar (low)							
5. Net Electric Output = 332 KW							
6. Application = Off (On) - Grid Power Supply							
7. Add Features = Redeployable, Robust Multi-fuel Grate, ORC System for Low Pressure, Low Water Consumption, High Reliability. Plant Elect. Efficiency is 19%, Calcium Hydroxide for the flue gas cleaning							
Fuel Price in US$/t	**-30**	**-20**	**-10**	**0**	**10**	**20**	**30**
LCOE in US$/MWh	71	100	129	159	188	217	246
Year of ROI	6	6	7	8	9	11	15
@$300/MWh Or 70 Naira / KWh							

4.3 Impact - Relationship between Waste-to-Energy, Environmental Quality and Sustainable Development: Secondary Data Results and Discussion

Table 4.78. Model 1 Variables Description

Variable	Description	Measurement
GDPC	GDP Per Capita	Billion US$
WTE	Waste to Energy	Combustible Renewable and Waste final energy consumption)
CO2	Carbon Emission	Kt
EXC	Exchange Rate	Real %
FDI	Foreign Direct Investment	2010 US$ in billion
GCF	Gross Capita Formation	Constant 2010 US$
LAB (HDI)	Human Capital Development Index	Constant 2010 US$

The mean of GDP per capita in the period under investigation was found to be \$7.39. The value was at the peak in the year 2013 to the tune of \$7.84 because of good oil price in global market which is the country's mainstay (main income). However, the feat was not long because of the oil price crash between year 2015 and 2016 at the global market which reflected in the GDP per capital decline to \$7.04. The standard deviation for GDP per capita was 0.27 which implies that the dispersion from the mean was not all that much. The closer the value to zero, the more the value for the gross domestic product per capita is stable within the period investigated. Model variables such as GDP per capita, exchange rate and gross domestic formation variables were positively skewed while others were negative (See Appendix B).

The distribution peakness or flatness degree is measured by Kurtosis, which should be zero to be normally distributed, else it is not. Gross domestic product per capita, waste to energy, Co2 emission, foreign direct investment, gross capital formation and human capital are all platykurtic at a threshold of 3, meaning that it is flat relative to the normal while exchange rate is the only variable found to be leptokurtic as indicated by greater than 3 output. The result Jarque-Bera showed that the distribution is normally distributed. In the period under investigation, it was found that one (US dollar) exchanged for about N150 (Nigerian currency). The highest exchange rate was observed in the year 2016 which was not unconnected with the policies of the federal government to place embargo on many staple foods and other items being imported into the country. Central bank was asked not to give US dollars to any person or firm in that line of business for importation so that there can be domestic solutions to the problems highlighted. At initial stage, an average consumer in Nigerian found it very difficult to cope, this made him to go to any length to get US dollar. The aftermath effect was the exponential rise in the exchange rate.

The standard deviation for exchange rate of 120.03 implies that the dispersion from the mean was very much and the widest among the variables in the model. The closer the value to zero, the more the value for the exchange rate is stable in the period under investigation. Foreign direct investment and gross capital formation were respectively seen to be on average of \$21.21billion and \$24billion (US dollars) while human capital was estimated to be 2.68 in the period. The higher the foreign direct investment as well as gross capital formation, the better the economy.

Correlation Analysis

The correlation matrix measures the relationship that exists between the variables in the model. The correlation between a variable and itself will always be unity as indicated the diagonal of the matrix. CO_2 emission, foreign direct investment, gross capital formation and human capital were each found to be positively related to the gross domestic product per capital in different magnitudes. The respective value of 0.097, 0.800, 0.920 and 0.917 for CO_2 emission, foreign direct investment, gross capital formation and human capital implies that a unit increase in kt CO_2 emission, a dollar increase into the Nigerian economy via foreign direct investment, a unit increase in the capital formation and a unit increase in the capital formation will cause gross domestic product per capital to improve by 9.7%, 80%, 92% and 92% respectively (See Appendix B).

However, a unit increase in the waste-to-energy and every naira loss against US dollar is found to respectively estimate to decline gross domestic product per capita by about 69% and 16%. The values of -0.055, -0.537, 0.561 and -0.699 for CO_2, FDI, GCF and LAB respectively imply that a unit increase in the kt CO_2 emission, a US dollar increase into the Nigerian economy via foreign direct investment, a unit increase in gross capital formation and human capital will bring down waste to energy by about 6 percent, 54 percent, 56 percent and 70 percent (See Appendix B). Every naira gain against US dollar in the international market is seen to add value to kt CO_2 emission by about 41 percent while a unit increase in the gross capital formation will only add slight margin of about 6 percent. However, kt CO_2 emission is seen to decline for every naira gain against US dollar in the international market by a margin of about 7 percent and unit increase in the human capital will shrink kt CO_2 emission. For every US dollar that comes to the country via foreign direct investment is seen to decline exchange rate by about 36 percent. In other words, there is naira gain against its counterpart currency of US. This may be unconnected to the availability of more foreign currency in Nigeria to meet the demands hence crushing unnecessary increase in the rate.

ARDL Bound Test: The bound test result shows that F-statistics is 30.7805 (See Appendix B). This value is greater than the upper critical value bound estimate, which depicts a long-run relationship among the model variables and supports the use of ARDL.

ARDL Cointegration (Short Run):

Shows the relationship that exists among independent variables of gross domestic product per capita, waste-to-energy, carbon-dioxide (CO_2) emission, exchange rate, foreign direct investment, gross capital formation and labour capital to dependent variable of gross domestic product per capita. (GDPC(-1)) 0.651380 coefficient shows positive relationship between current GDP per capita and gross domestic product per capital (GDPC) in the previous year (See Appendix B). The economic implication is if other model variables remain the same, for every $1 increase in previous year GDPC, the GDPC improves by about 65 US cent. The estimate was found to be statistically significant at 5 percent as the p-value was found to be 0.0036 and t-value was far beyond 2 threshold. (GDPC(-3)) -0.154730 coefficient shows negative relationship between the GDPC in the last 3 years and the current GDPC in the model provided other variables remain the same, for every $1 increase in the previous 3 year GDPC, the GDPC will decline by about 15 US cent.

The estimate was found to be statistically significant at 10 percent as the p-value was found to be 0.0727 and t-value (absolute) was beyond 2 threshold. -0.005369 for (WTE) indicates inverse relationship between the current waste-to-energy and the current gross domestic product per capital in the model provided other variables remain the same, for every 1 unit increase in kt waste -to- energy in the current year, GDPC declines by 0.54 percent. However, the estimate was not statistically significant at 10 percent. (WTE(-2)) 0.009526 coefficient depicts a relationship that is weak but positive between waste -to-energy (WTE) in the previous two years and the GDPC in the model provided other variables remain the same. For every 1 unit increase in kt waste -to- energy in the previous two years, GDPC improves slightly by 0.95 percent. This estimate was found to be statistically significant even at 5 percent (See Appendix B).

This may not be unconnected to millions of dollars (US) waste to energy is capable to add to the value of goods and services provided in Nigerian economy on annual basis. The coefficient of -0.334664 for (CO_2(-1)) shows inverse relationship between emission in the previous year and gross domestic product per capita. If other model variables remain the same, for every kt emission increase in the previous year, GPDC comes down by about 33 percent. This may be so because of the effect of air pollution which include photochemical smog, acid rain, death of forests, global warming and among others which will definitely reduce the rate at which production should grow in an economy. The estimate was found to be statistically significant at 5 percent as the p-value was found to be 0.0062 and t-value (absolute) was far beyond 2 threshold. (EXC (-2)) -0.000578 coefficient indicates that inverse relationship exists between exchange rate in the previous 2 years and GDPC. If other model variables remain the same, or every ₦1 loss against dollar (USD) as a result of buying and selling in global market, GDPC comes down by about slight margin of 0.057 percent (See Appendix B).

This should not come as surprise because Nigerian economy is very active in the foreign exchange market. The estimate was found to be statistically significant at 5 percent as the p-value was found to be 0.0058 and absolute t-value was far beyond 2 threshold. (FDI (-3)) -0.062857 value shows an inverse-relationship between foreign direct investment (FDI) in the previous three years and GDPC. If other model variables remain the same (constant), for every $1 that comes into Nigerian economy via investment, gross domestic product per capita comes down by margin of 6.2 percent. This is so because US dollars that come into the country are from foreigners which do not form part of the computations for gross domestic product.

The estimate was found to be statistically significant at 5 percent as the p-value was found to be 0.0065 and absolute t-value was far beyond the threshold of 2. (GCF(-1)) -0.050982 coefficient shows inverse-relationship between gross capital formation (GCF) in the previous year and GDPC. If other model variables remain the same, for every 1 unit increase in GCF in the previous year, GDPC comes down by margin of 5 percent. The estimate was found to be statistically significant at 10 percent as the p-value was found to be 0.0823 and absolute t-value was beyond the threshold of 2.

ARDL Co - Integrating (Long Run)

From the table above (Table 5.3b) that shows the relationship that exists between independent variables of waste-to-energy, CO_2 emission, exchange rate, foreign direct investment and gross capital formation with their respective short form of WTE, CO_2, EXC, FDI and GCF while gross domestic product per capita (GDPC) represented the dependent variable in the long run.

WTE -0.028998 coefficient shows inverse-relationship between waste-to-energy (WTE) and GDPC at long run meaning that if other factors in the model are not allowed to change, for every kt of WTE, GDPC declines by about 3 cents. This may be so because Nigeria as a country has faster population growth rate than the gross domestic product (GDP). The estimate enjoys the support of statistical significant at 5 percent (See Appendix B). CO_2 0.355729 coefficient depicts a relationship that is positive between CO_2 emission and GDPC meaning, if other model factors remain the same, for every kt of CO_2 emission, GDPC goes up by about 36 US cents. This may be so because carbon dioxide (CO_2) emissions absorbed by plants boost the photosynthesis thereby increasing the agricultural produce which is one of the areas that contributed so much to the gross domestic product (GDP).

The estimate enjoys the support of statistical significant at 5 percent. Exchange rate coefficient of 0.000245 implies positive relationship with GDPC, meaning if other model factors remain the same (constant), for every ₦1 gain against dollar (USD) at international market, GDPC goes up by a slight margin of 0.02 US cents. This may be so because monetary policy authority in Nigeria (CBN) is gradually using other currency as a means of settlement in the international market. Also, every gain in currency in favour of Nigeria will add value to the GDP. The estimate enjoys the support of statistical significant at 10 percent. Coefficient of 0.12092 for FDI indicates positive relationship with GDPC, meaning if other model factors remain the same, for every $1 that comes into the country via foreign investment, GDPC raise is expected to be 12 US cents. This is because Nigerian citizens will get jobs and other values chains that will promote the well-being of the citizens. The estimate enjoys the support of statistical significant at 5 percent (See Appendix B).

Keeping all other variables in the model constant, a unit increase in the gross capital formation tends to boost the gross domestic product per capita by 21 percent. The p-value of 0.0003 shows that the estimate enjoys the support of statistical significant at 5 percent. If waste to energy, Co2 emission, exchange rate, foreign direct investment, gross capital formation are all zeros, gross domestic product per capita will be $1.73 (USD). In other words, other factors not included in the model will contribute about $1.73 (USD) for an average person living in Nigeria. The p-value of 0.0048 shows that the estimate enjoys the support of statistical significant at 5 percent (See Appendix B).

4.3.1 Analysis of Causal Relationship

The null hypothesis that waste-to-energy (WTE), CO_2 emission does not Granger cause gross domestic per capita (GDPC) is rejected each and for both sides at 10 percent significant level. In other words, both WTE and CO_2 emission granger cause GDPC. The null hypothesis that GDPC does not Granger cause exchange rate, the null hypothesis that GDPC does not granger cause foreign direct investment (FDI) and the null hypothesis that gross capital formation (GCF) does not granger cause gross domestic product per capita are all rejected but in one way at 10 percent significant level. This implies that GDPC granger cause exchange rate and as well granger cause FDI, and that GCF does granger cause GDPC.

Also, the null hypothesis that GDPC does not Granger cause human capital, the null hypothesis that WTE does not granger FDI and the null hypothesis that FDI does not granger cause CO_2 emission are all rejected but in one way at 10 percent significant level. This means that human capital does not granger cause GDPC but GDPC granger cause human capital. This position holds for other variables in the same category. The null hypothesis that GCF does not Granger cause exchange rate and the null hypothesis that GCF does not granger cause FDI are each accepted in bidirectional ways at 10 percent significant level. This implies that GCF does not granger cause exchange rate and exchange rate does not granger cause GCF. The same thing applies to GCF and FDI.

4.3.2 Discussion of Findings

Granger cause gross domestic per capita (GDPC (-1)) 0.651380 coefficient shows a relationship that is positive between current GDPC and GDPC in the previous year. The economic implication is, if other model variables remain the same, for every $1 raise in the previous year GDPC, the current GDPC improves by about 65 cent (US). The estimate was found to be statistically significant at 5 percent as the p-value was found to be 0.0036 and t - value was far beyond 2 thresholds. (GDPC (-3)) -0.154730 coefficient depicts a negative relationship between GDPC in the last 3 years and the current GDPC in the model provided other variables remain the same, for every \$1 increase in the previous 3 year GDPC, the current GDPC will decline by about 15 US cent. The estimate was found to be statistically significant at 10 percent as the p-value was found to be 0.0727 and t - value (absolute) was beyond 2 threshold.

From the table that shows the relationship that exists between independent variables of waste-to-energy, CO_2 emission, exchange rate, foreign direct investment and gross capital formation with their respective short form of WTE, CO_2, EXC, FDI and GCF while gross domestic product per capita (GDPC) represented the dependent variable in the long run. This finding contrast the report of Acaravci and Ozturk (2010), whose empirical analysis show evidence of a long-run positive relationship between the independent variables for some of the countries tested, however, there was no evidence of a positive long-run relationship for others; therefore, the study does not provide a unanimous result. Acaravci and Ozturk conclude that the EKC hypothesis cannot be seen as valid for most of the European countries. However, WTE -0.028998 coefficient shows inverse-relationship between WTE and GDPC at long run, meaning that if other factors in the model are not allowed to change, for every kt of waste to energy, gross domestic product per capita declines by about 3 cents. This may be so because Nigeria as a country has faster population growth rate than the gross domestic product (GDP). The estimate enjoys the support of statistical significant at 5 percent. CO_2 0.355729 coefficient depicts a relationship that is positive between CO_2 emission and GDPC, meaning that if other model factors remain the same, for every kt of CO_2 emission, GDPC goes up by about 36 US cents. This result was consistent with the report of World Development (1992), where they reported a relationship between ambient concentrations of sulphur dioxide and per capita GDP in 47 cities distributed over 31 countries. The EKC follows an inverted U-shape where per capita income and sulphur dioxide (SO_2) concentration are positively correlated to a certain point at which the trend turns and the opposite relationship can be observed.

This may be so because carbon dioxide emissions absorbed by plants boost the photosynthesis thereby increasing the agricultural produce which is one of the areas that contributed so much to the GDP. The estimate enjoys the support of statistical significant at 5 percent. Exchange rate coefficient of 0.000245 implies positive relationship with GDPC, meaning if other model factors remain the same, for every ₦1 gain against dollar (USD) in the international market, GDPC goes up by a slight margin of 0.02 US cents. This may be so because monetary policy authority in Nigeria (CBN) is gradually using other currency as a means of settlement in the international market. Also, every gain in currency in favour of Nigeria will add value to the GDP. The estimate enjoys the support of statistical significant at 10 percent. Coefficient of 0.12092 for foreign direct investment indicates positive relationship with GDPC, meaning if other model factors remain the same, for every $1 that comes into the country via foreign investment, GDPC raise is expected to be 12 US cents. This is because Nigerian citizens will get jobs and other values chains that will promote the well-being of the citizens. The estimate enjoys the support of statistical significant at 5 percent. Keeping all other variables in the model constant, a unit increase in the GCF tends to boost the GDPC by 21 percent.

The p-value of 0.0003 shows that the estimate enjoys the support of statistical significant at 5 percent. If waste to energy, CO_2 emission, exchange rate, foreign direct investment, gross capital formation are all zeros, gross domestic product per capita will be $1.73 (USD). In other words, other factors not included in the model will contribute about $1.73 (USD) for an average person living in Nigeria. The result supported the assertion of Yanyan *et al*., (2022) whose findings indicated that FDI inflows are positively associated with carbon emissions, as well as both economic developments. It implies that although FDI inflows tend to increase the emissions of carbon dioxide, they are more likely to mitigate carbon emissions in countries with higher levels of economic development and regulatory quality. However, the p-value of 0.0048 shows that the estimate enjoys the support of statistical significant at 5 percent. To understand which variable, cause the other, pairwise Granger causality test was employed on the variables on the model. At 10 percent, the null hypothesis that waste -to- energy does not Granger cause GDPC and that CO_2 emission does not Granger cause GDPC are rejected each and for both directions. This implies that as more and more effort are put into WTE transformation to energy, GDP is geared upward.

This is not unconnected with the value chain created in the process and the number of people that got involved which added to the economic value of goods and services created in the period. The null hypothesis that GDPC does not Granger cause exchange rate, that GDPC does not granger cause FDI and that GCF does not granger cause GDPC are all rejected but in one way at 10 percent significant level implies that these pair of variables does not cause each other but only one cause the other. A contrasting result to the finding of Lan *et al*., (2021), who stated that there are long-term stable and unidirectional causal relationship between the exchange rate and FDI inflow. The more we create goods and services toward meeting our domestic needs the lesser US dollar is needed for importation. The rejection of null hypothesis that gross domestic product per capita does not Granger cause human capital rejected in one way at 10 percent significant level implies that as individual worker in the economy is thriving to be better via education, be it formal or informal, values are added or created to the portfolio of goods and services in the economy thereby causing the GDP to rise.

Table 4.79. Model 2 Variable Description

Variable	Description	Measurement
SD	Sustainable Development	GDP Per Capita US$ (Constant 2010)
WTE	Waste to Energy	Combustible Renewable and Waste (% of total final energy consumption)
EF	Environmental Footprint	Total greenhouse gas emissions (kt of CO2 equivalent)
GNNI	Green National Net Income	Adjusted net national income (constant 2010 US$)
HDI	Human Development Index	Life expectancy at birth, total (years)

Table 4.80. Average of the Variables in the Model (1981 – 2017)

	LOG(SD)	LOG(WTE)	LOG(EF)	LOG(GNNI)	LOG(HDI)
Mean	7.394468	4.339318	12.34506	25.65635	3.960363
Median	7.263262	4.333679	12.57122	25.56359	3.918031
Maximum	7.848970	4.388360	12.83314	26.53712	4.107635
Minimum	7.048496	4.288979	11.79742	24.79629	3.881994
Std. Dev.	0.274093	0.030311	0.371068	0.565052	0.071807
Skewness	0.499828	-0.055610	-0.321850	0.278412	0.865790
Kurtosis	1.607913	1.602206	1.425052	1.575514	2.218619
Jarque-Bera	4.528215	3.031220	4.462832	3.606289	5.563758
Probability	0.103923	0.219674	0.107376	0.164780	0.061922
Sum	273.5953	160.5548	456.7671	949.2850	146.5334
Sum Sq. Dev.	2.704576	0.033075	4.956897	11.49423	0.185626
Observations	37	37	37	37	37

Respective average values for sustainable development, waste to energy, environmental footprint, green national net income and human development index were estimated to be $7.39, 4.33%, 12.34kt, $25.65 and 3.96 years life expectancy. This implies that $7.39 gross domestic per capital is attributed to sustainable development, this finding is consolidating the World Bank report (2016), that solid waste management is critical for sustainable, healthy, and inclusive cities and communities. However, 4.33 percent of the total final energy consumption as proxy of combustible renewable and waste is attributed to waste-to-energy, 12.34 kt of CO_2 as proxy of total greenhouse gas emissions while human development index as proxy to life expectancy at birth is expected to be about 4 years from birth. Standard deviation measures how an estimate or output deviates from the center. 0.565052 and 0.030311, respectively for green national net income and waste-to-energy show that green national net income is the most deviated while waste-to-energy is the least deviated variable in the model.

In other words, waste-to-energy is the most reliable and predictable followed by human development index, while green national net income was found to be the most volatile. All the model macroeconomic variables are positively skewed except waste -to- energy and environmental footprint. The distribution flatness or peakness degree is measured by Kurtosis, which is zero to be normally distributed, else it is not. Sustainable development, waste -to- energy, environmental footprint, green national net income and human development index are platykurtic at a threshold of 3. All the macroeconomic variables in the model were found to be positively skewed except waste-to-energy and environmental footprint. Kurtosis measures the degree of peakness or flatness of a distribution. The Kurtosis of a normal distribution is zero otherwise, it is not normally distributed. Using a threshold of 3, sustainable development, waste-to-energy, environmental footprint, green national net income and human development index are platykurtic, which depicts a flat distribution when compared to the normal. The result Jarque-Bera showed that the distribution is normally distributed.

Table 4.81. Correlation Matrix

	SD	WTE	EF	GNNI	HDI
SD	1.000000	-0.688459	0.579811	0.982627	0.943090
WTE	-0.688459	1.000000	-0.683837	-0.707185	-0.715151
EF	0.579811	-0.683837	1.000000	0.672912	0.679285
GNNI	0.982627	-0.707185	0.672912	1.000000	0.955583
HDI	0.943090	-0.715151	0.679285	0.955583	1.000000

All the variables in the model were found to have positive correlation with sustainable development except waste to energy. However, waste to energy exhibits strong negative relationship with all the variables in the model. This should not come as a surprise because as more effort is intensified to increase the level of sustainable development, lesser waste will be available for conversion into energy.

Waste-to-energy and environmental footprint, waste-to-energy and green national net income and waste to energy and human development index were respectfully negatively correlated with -0.683837, -0.707185 and -0.715151. For every 100 percent waste to energy, environmental footprint will go down by about 68 percent because as more combustible renewable and waste are being consumed, the total greenhouse gas emissions tend to give way.

Positive correlation coefficient of 0.679285 between environmental footprint and human development index shows that as people are taking measures to improve the level of Kt of CO_2 emission, life expectancy at birth is significantly improved by about 68 percent. Green national net income proxy of adjusted net national income and human development index exhibited strong positive relationship which implies that every US dollar would cause human development index to soar by about 96 percent, this should not come as a surprise as every increase in the adjusted net national income will have levels of impact on humanity for good.

Table 4.82. Unit Root Test

Method	Statistic	Prob.**
ADF - Fisher Chi-square	18.2627	0.0507
ADF - Choi Z-stat	-1.89436	0.0291

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Table 4.83. Intermediate ADF Test Result

Series	Prob.	Lag	Max Lag	Obs
LOG(SD)	0.3748	0	8	36
LOG(WTE)	0.1925	0	8	36
LOG(EF)	0.5877	0	8	36
LOG(GNNI)	0.0368	0	8	36
LOG(HDI)	0.0694	3	8	33

Method	Statistic	Prob.**
ADF - Fisher Chi-square	66.9870	0.0000
ADF - Choi Z-stat	-6.36290	0.0000

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table 4.84. Intermediate ADF Test Results D

Series	Prob.	Lag	Max Lag	Obs
D(LOG(SD))	0.0037	0	8	35
D(LOG(WTE))	0.0002	0	8	35
D(LOG(EF))	0.0000	0	8	35
D(LOG(GNNI))	0.0038	0	8	35
D(LOG(HDI))	0.0649	3	8	32

Table 4.85. Bound Test

ARDL Bounds Test

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	19.23678	4

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	3.03	4.06
5%	3.47	4.57
2.5%	3.89	5.07
1%	4.4	5.72

Table 4.86. ARDL Cointegrating and Long Run Form Results

ARDL Cointegrating And Long Run Form

Dependent Variable: LOG(SD)

Selected Model: ARDL(3, 3, 4, 3, 2)

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(SD(-1))	0.942919	0.174480	5.404178	0.0002
DLOG(SD(-2))	0.447295	0.149008	3.001811	0.0110
DLOG(WTE)	-0.371452	0.331472	-1.120612	0.2844
DLOG(WTE(-1))	0.078321	0.324592	0.241291	0.8134
DLOG(WTE(-2))	1.185007	0.289005	4.100298	0.0015
DLOG(EF)	-0.043826	0.057173	-0.766545	0.4582
DLOG(EF(-1))	0.017127	0.056426	0.303526	0.7667
DLOG(EF(-2))	0.118844	0.052238	2.275067	0.0421
DLOG(EF(-3))	0.201535	0.058721	3.432041	0.0050
DLOG(GNNI)	0.412180	0.051440	8.012763	0.0000
DLOG(GNNI(-1))	-0.193219	0.076255	-2.533855	0.0262
DLOG(GNNI(-2))	-0.134470	0.073379	-1.832548	0.0918
DLOG(HDI)	-87.362573	38.388352	-2.275757	0.0420
DLOG(HDI(-1))	95.767877	35.180428	2.722192	0.0185
D(@TREND())	-0.000196	0.005823	-0.033694	0.9737
CointEq(-1)	-2.183916	0.256328	-8.520011	0.0000

Cointeq = LOG(SD) - (-1.2527*LOG(WTE) -0.1779*LOG(EF) + 0.3924
*LOG(GNNI) + 0.6259*LOG(HDI) + 2.4500 -0.0001*@TREND)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(WTE)	-1.252701	0.185188	-6.764478	0.0000
LOG(EF)	-0.177940	0.082132	-2.166515	0.0511
LOG(GNNI)	0.392440	0.028589	13.726977	0.0000
LOG(HDI)	0.625945	0.379810	1.648049	0.1253
C	2.449950	1.813084	1.351261	0.2015
@TREND	-0.000090	0.002664	-0.033723	0.9737

ARDL Bound Test

The bound test result shows that F-statistic value of 19.23 for ARDL test is greater than the upper value of both critical value bounds hence supporting the use of Autoregressive Distributive Lag (ARDL).

ARDL Cointegrating (Short Run)

From the above table (Table 5.6a) shows the relationship that exists between the independent variables of waste to energy, environmental footprint, green national net income and human development index with their respective short form of WTE, EF, GNNI and HDI while sustainable development (SD) represented the dependent variable in the short-run.

The coefficient 0.942919 of WtE shows a relationship that is positive between sustainable development in previous year and current year sustainable development. It shows that every dollar on GDPC as proxy of sustainable development in the last year will cause current sustainable development to soar by about 94 US cent. The t-statistic value of 5.404178 which goes beyond the threshold of two hence validates the statistical significance of the relationship at 10 percent level.

Relationship between waste-to-energy in the previous year and the current sustainable development was found to be negative to the magnitude of 0.371452 for every 100 percent increase of combustible renewable and waste in the current year, sustainable development tends to shrink by 37 percent. This relationship however, was not affirmed because the t-statistic (absolute) is not approximated to 2. Environmental footprint 0.118844 coefficient in the previous two years indicates weak positive relationship between the current sustainable development and the previous two years environmental footprint. The t-statistic value of 2.275067 which goes beyond the threshold of two hence validates the statistical significance of the relationship at 10 percent level. Steady increase in MSW generation is driven by population growth, increasing Gross Domestic Product (GDP) (with associated consumption of consumer products), and urbanization. Countries with higher GDP generally generate a higher amount of waste (Agamuthu *et al*., 2020).

Inverse relationship was established between green national income in the last one year and the current sustainable development to the tune of 0.193219 meaning that every dollar (USD) increase in the green national net income in previous year will cause the current year sustainable development to shrink by about 19.3 percent holding other variable in the model constant. The t-statistic value of 2.275067 which goes beyond the threshold of two hence validates the statistical significance of the relationship at 10 percent level.

The coefficient of 95.767877 indicates positive relationship between the current sustainable development and the human development index in the previous year which implies that every increase in the human development in the previous year will shut up the current sustainable development. The t-statistic value of 2.722192 which goes beyond the threshold of two hence validates the statistical significance of the relationship at 10 percent level.

ARDL Co - integrating (Long Run)

From the table (Table 5.6b) that shows the relationship that exists between independent variables of waste to energy, environmental footprint, green national net income and human development index with their respective short form of WTE, EF, GNNI and HDI while sustainable development (SD) represented the dependent variable in the long run.

In Porter's theory, green public procurement can be in form of a properly designed environmental policy instrument capable to conjugate environmental benefits and competitive improvement in an economic performance of a country. Of course, the high impact of green public procurement on economic activities positively influences the probability that a country invests in innovative solutions as pointed out by Testa *et al*., (2011).

The coefficient -1.252701 of WtE implies that every percentage of combustible renewable and waste as proxy of waste to energy tends to decrease the sustainable development by over 1.25 percent. this may be that as more and more waste is turned to energy, the negative impact might be felt in the which in-turn decreases the level of sustainable development. The absolute t-statistic value of 6.764478 goes beyond the threshold of two hence validates the statistical significance of the relationship at 10 percent level.

Also, environmental footprint and sustainable development exhibited weak negative relationship in the long run to the tune of -0.177940 which implies that every unit increase in kt of Co2 total greenhouse gas emissions as proxy of environmental footprint sustainable development will shrink by about 17.7 percent. The absolute t-statistic value of 2.166515 goes beyond the threshold of two hence validates the statistical significance of the relationship at 10 percent level.

The coefficient 0.392440 of WtE indicates weak positive relationship between green national net income proxy of adjusted net national income and the sustainable development. It might be that as government put measures in place which leads to increase in the adjusted net national income, substantial aspect (about 40 percent) of such increase may be used for sustainable development. The t-statistic value of 13.726977 goes beyond the threshold of two hence validates the statistical significance of the relationship at 10 percent level.

Human development index and sustainable development exhibits relatively strong relationship to the tune of 0.625945 which connotes that every year increase in the life expectancy at birth as proxy of human development index, sustainable development tends to soar by about 63 percent. This should not come as a surprise as one form of training or the other will definitely gear up the level of sustainable development. However, the relationship was not supported at 10 percent significant level.

If waste-to-energy, environmental footprint, green national net income and human development index were all zero at long run, sustainable development will still be around 2.449950 (US dollar) gross domestic product per capita. This will be so as a result of some other factors capable of inducing sustainable development but are not captured in the model. However, the estimate here is statistically insignificant as the t-statistics does not go beyond threshold of 2 and the p-value is more than 10 percent (See Appendix D).

Table 4.87.: Model 3 Variable Description

Variable	Description	Measurement
EQ	Environmental Quality	Total greenhouse gas emissions (kt of CO_2 equivalent)
WTE	Waste-to-Energy	Combustible Renewable and Waste (% of total final energy consumption)
FOSS	Fossil Energy Consumption	US$ (Constant 2010)
Y	Per Capita Income	US$ (Constant 2010)
ENE	Energy Consumption	US$ (Constant 2010)
CAP	Capital Investment	GFCF as a % of GDP
URB	Urbanization	Urban Population % of Total Population
TRA	Trade Intensity	Trade Intensity Ratio % of GDP
LQI	Land Quality Index	Land under cereal production (hectares)

Table 4.88. Average of the Variables in the Model 3 (1981 – 2017)

	LOG(EQ)	LOG(WTE)	LOG(FOSS)	LOG(GDPC)	LOG(LQI)	LOG(TRA)	LOG(URB)	LOG(CAP)
Mean	12.34506	4.339318	2.972599	7.394468	16.51098	3.369131	3.542329	3.464578
Median	12.57122	4.333679	2.963514	7.263262	16.64955	3.531717	3.535262	3.599547
Maximum	12.83314	4.388360	3.128723	7.848970	16.85701	3.975523	3.902356	4.492965
Minimum	11.79742	4.288979	2.763431	7.048496	15.39747	2.212206	3.121087	2.651037
Std. Dev.	0.371068	0.030311	0.081412	0.274093	0.364411	0.506048	0.225312	0.539154
Skewness	-0.321850	-0.055610	-0.087347	0.499828	-2.000971	-1.041178	-0.126143	-0.028291
Kurtosis	1.425052	1.602206	2.785197	1.607913	6.052722	3.021082	1.973057	2.014727
Jarque-Bera	4.462832	3.031220	0.118181	4.528215	39.05759	6.685666	1.723984	1.501527
Probability	0.107376	0.219674	0.942621	0.103923	0.000000	0.035337	0.422320	0.472006
Sum	456.7671	160.5548	109.9862	273.5953	610.9063	124.6578	131.0662	128.1894
Sum Sq. Dev.	4.956897	0.033075	0.238602	2.704576	4.780634	9.219062	1.827563	10.46475
Observations	37	37	37	37	37	37	37	37

In the period under investigation, 12.34kt, 4.33%, \$2.97 and \$7.39 was respectively estimated for the average environmental quality, waste to energy, fossil energy consumption and per capital income. 12.34 kt of CO_2 for total greenhouse gas emissions as proxy for environmental quality seems to be lower which may be attributed to the environmental policies put in place in the recent time. \$7.39 (US dollar) for per capital income can be seen to be small compared to what obtains in the advanced economy. This small value can be traced to the very large number of people without productive employment in Nigeria.

Land under cereal production as proxy for land quality index, trade intensity ratio expressed as percentage of gross domestic product for trade intensity, urbanization and capital investment were averagely and respectively estimated to be 16.51 hectares, 3.36 percent, 3.54 percent and 3.46 percent. Land quality index of 16.51 hectares for the period under review on average shows that the land is relatively good.

Standard deviation measures how an estimate or output deviates from the centre. 0.371068, 0.030311, 0.081412 and 0.274093 respectively for environmental quality, waste to energy, fossil energy consumption, and gross domestic product per capital. Waste to energy was estimated to be the least variable that deviates from the centre. In other words, waste to energy was the most predictable variable while capital investment was found to be the most fluctuated variable among the variables in the model. All the macroeconomic variables in the model were found to be negatively skewed except GDPC. The distribution flatness or peakness degree is measured by Kurtosis, which is zero to be normally distributed, else it is not. Environmental quality, waste -to- energy, fossil energy consumption, gross domestic product per capita, urbanization, and land quality index are platykurtic at a threshold of 3, which implies a flat distribution when compared to the normal. The result Jarque-Bera showed that the distribution is normally distributed.

Table 4.89. Correlation Matrix

	EQ	WTE	FOSS	GDPC	LQI	TRA	URB	CAP
EQ	1.000000	-0.683837	-0.379521	0.579811	0.681748	0.558595	0.843084	-0.806874
WTE	-0.683837	1.000000	-0.227999	-0.688459	-0.478930	-0.361248	-0.758694	0.642095
FOSS	-0.379521	-0.227999	1.000000	-0.288523	-0.347047	-0.230637	-0.432661	0.471861
GDPC	0.579811	-0.688459	-0.288523	1.000000	0.203425	0.077444	0.834041	-0.636985
LQI	0.681748	-0.478930	-0.347047	0.203425	1.000000	0.635859	0.663631	-0.781933
TRA	0.558595	-0.361248	-0.230637	0.077444	0.635859	1.000000	0.446464	-0.543309
URB	0.843084	-0.758694	-0.432661	0.834041	0.663631	0.446464	1.000000	-0.922616
CAP	-0.806874	0.642095	0.471861	-0.636985	-0.781933	-0.543309	-0.922616	1.000000

Virtually all the variables in the model were found to have positive correlation with environmental quality except waste to energy, fossil energy consumption and capital investment. However, waste to energy and capital investment exhibit strong negative relationship with environmental quality. It is not unexpected to have environmental quality as expressed as total greenhouse gas emissions and waste energy proxy of combustible renewable and waste going different direction. As more and more effort is put in place to increase every waste to energy via combustible renewable and waste, environmental quality decreases by over 68 percent. On every US dollar increase as a result of fossil fuel consumption, environmental quality will come down by about 38 percent. This is so because the depletion in the remains will cause environmental quality to rise.

The coefficient 0.579811 of WtE implies strong positive correlation between environmental quality and gross domestic per capital. This is made possible because as gross domestic product per capital is increasing, a sensible country such as Nigeria, will find ways to improve the quality of the environment. Between waste-to-energy and every other variable in the model, there was inverse relationship varying from one magnitude to the other except capital investment. For every percentage increase in the combustible renewable and waste, Kt of total greenhouse gas emissions as proxy for environmental quality tends to shrink by about 23 percent. In Coarse theory propounded by Professor Ronald H. Coase, on fundamental conservative insight about entitlements and property rights. For every entitlement and property right, transaction cost must be involved. The more the parcel of land one has title on, the more the transaction cost.

Land quality index and urbanization exhibit positive correlation to the tune of 0.663631 which implies that every percentage increase in the total population, land under cereal production as proxy for land quality index tends to go up by 66 percent.

Table 4.90. Unit Root Test

Intermediate ADF test results UNTITLED

Series	Prob.	Lag	Max Lag	Obs
LOG(EQ)	0.5877	0	8	36
LOG(WTE)	0.1925	0	8	36
LOG(FOSS)	0.1279	0	8	36
LOG(GDPC)	0.3748	0	8	36
LOG(LQI)	0.1394	0	8	36
LOG(TRA)	0.6834	0	8	36
LOG(URB)	0.0010	8	8	28
LOG(CAP)	0.1256	0	8	36

Intermediate ADF test results D(UNTITLED)

Series	Prob.	Lag	Max Lag	Obs
D(LOG(EQ))	0.0000	0	8	35
D(LOG(WTE))	0.0002	0	8	35
D(LOG(FOSS))	0.0000	0	8	35
D(LOG(GDPC))	0.0037	0	8	35
D(LOG(LQI))	0.0002	0	8	35
D(LOG(TRA))	0.0000	0	8	35
D(LOG(URB))	0.0000	0	8	35
D(LOG(CAP))	0.0001	0	8	35

ARDL Bounds Test

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	5.643745	7

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.38	3.45
5%	2.69	3.83
2.5%	2.98	4.16
1%	3.31	4.63

Table 4.91. ARDL Cointegrating And Long Run Form

ARDL Cointegrating And Long Run Form

Dependent Variable: LOG(EQ)

Selected Model: ARDL(1, 3, 0, 1, 1, 1, 1, 3)

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(WTE)	-1.689666	5.186900	-0.325757	0.7494
DLOG(WTE(-1))	5.016775	1.297790	3.865630	0.0017
DLOG(WTE(-2))	-2.749095	1.291752	-2.128191	0.0516
DLOG(FOSS)	0.050290	1.279510	0.039304	0.9692
DLOG(GDPC)	0.064888	0.371399	0.174712	0.8638
DLOG(LQI)	0.136216	0.286510	0.475431	0.6418
DLOG(TRA)	0.001663	0.078820	0.021096	0.9835
DLOG(URB)	1.010322	6.276682	0.160964	0.8744
DLOG(CAP)	0.690875	0.231278	2.987199	0.0098
DLOG(CAP(-1))	-0.606933	0.225392	-2.692783	0.0175
DLOG(CAP(-2))	0.689210	0.218796	3.150015	0.0071
D(@TREND())	0.267351	0.057146	4.678347	0.0004
CointEq(-1)	-0.754484	0.148019	-5.097217	0.0002

Cointeq = LOG(EQ) – (0.6280*LOG(WTE) + 0.0667*LOG(FOSS) + 0.8499 *LOG(GDPC) + 0.7700*LOG(LQI) + 0.4424*LOG(TRA) -17.5544 *LOG(URB) + 0.2169*LOG(CAP) + 43.7591 + 0.3543*@TREND)

Table 4.92. Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(WTE)	0.628022	7.048021	0.089106	0.9303
LOG(FOSS)	0.066655	1.693434	0.039361	0.9692
LOG(GDPC)	0.849859	0.486023	1.748598	0.1022
LOG(LQI)	0.770017	0.414521	1.857608	0.0844
LOG(TRA)	0.442422	0.132109	3.348904	0.0048
LOG(URB)	-17.554407	4.624633	-3.795849	0.0020
LOG(CAP)	0.216905	0.524088	0.413872	0.6852
C	43.759112	46.212624	0.946908	0.3597
@TREND	0.354349	0.069437	5.103181	0.0002

ARDL Bound Test

The bound test result shows that F-statistic value of 5.64 for ARDL test is greater than the upper value of both critical value bounds thereby giving support for the use of Autoregressive Distributive Lag (ARDL).

ARDL Cointegrating (Short Run)

From the above table (Table 5.2.7a) shows the relationship that exists between the independent variables of waste to energy, fossil energy consumption, gross domestic product per capita, land quality index, trade intensity, urbanization and capital investment with their respective short form of WTE, FOSS, GDPC, LQI, TRA, URB and CAP while environmental quality (EQ) represented the dependent variable in the short-run.

The coefficient of -1.689666 indicates inverse relationship between environmental quality and waste to energy both in the current year. It shows that every percent of combustible renewable and waste increase, environmental quality as represented by total greenhouse gas emissions comes down by about 1.7 kt. The absolute t-statistic value of 0.3257 is far below the threshold of two hence invalidates the statistical significance of the relationship at 10 percent level.

The coefficient 5.016775 of waste to energy in the previous year implies positive relationship and that every percent of combustible renewable and waste increase, environmental quality as represented by total greenhouse gas emissions goes up by about 5.016kt. This may be so because environmental policies, most of the time, do not have immediate effect until the following year. However, the relationship enjoys the support of statistical significance as t-statistic value (absolute) above two threshold.

Environmental quality and fossil energy consumption exhibit weak and positive relationship. Provided other factors were kept constant, every US dollar increase as a result of fossil energy consumption tends to cause environmental quality as represented by total greenhouse gas emissions to increase by about 5 percent of kt.

The coefficient 0.064888 of WtE of gross domestic product per capita is an indication that every increase of one US dollar will cause environmental quality as represented by total greenhouse gas emissions goes up by about 6 percent of kt. This may be so because an improvement in the GDPC is an improvement in the well-being of an individual which will definitely add value to the land quality.

In Porter's theory, green public procurement can be in form of a properly designed environmental policy instrument capable to conjugate environmental benefits and competitive improvement in the economic performance of a country. Of course, the high impact of green public procurement on economic activities positively influences the probability that a country invests in innovative solutions as pointed out by Testa *et al*., (2011). Land quality index and environmental quality will not be a surprise to them going towards the same direction as manifested here. The coefficient of 0.136216 for land quality index represented as hectares of land for cereal production implies that every hectare increase will cause environmental quality to rise by about 14 percent of kt. T-statistic value of 0.3257 (absolute) lies below the threshold of two, hence invalidates the statistical significance of the relationship at 10 percent level.

ARDL Cointegrating (Long Run)

From the above table (Table 5.2.7b) shows the relationship that exists between the independent variables of waste to energy, fossil energy consumption, gross domestic product per capita, land quality index, trade intensity, urbanization and capital investment with their respective short form of WTE, FOSS, GDPC, LQI, TRA, URB and CAP while environmental quality (EQ) represented the dependent variable in the long-run.

Meanwhile, 0.628022 Coefficient indicates strong positive relationship between environmental quality as represented by total greenhouse gas emissions and waste to energy proxy of combustible renewable and waste which implies that every percentage increase in the combustible renewable and waste environmental quality tends to increase about 63 percent of kt. This may be so because as efforts are intensified to convert virtually all waste to energy, more gas emissions is likely to be generated. T-statistic (absolute) value is far below 2 threshold, thus invalidates statistical significance of the relationship at 10 percent level.

Fossil energy consumption exhibits weak but positive relationship with environmental quality. This is not unexpected as every remains is turned into energy for consumption, there is likelihood to add to total greenhouse gas emissions and waste to energy proxy of combustible renewable and waste during the transition. Every increase in the US dollar as result of fossil energy consumption will add a margin of about 7 percent to the kt of Co2. T-statistic (absolute) value is far below 2 threshold, thus invalidates statistical significance of the relationship at 10 percent level.

Environmental quality and gross domestic product per capita have a strong positive association, as seen by the coefficient of 0.849859 for GDP per capita. The standard of living for each individual is improved as the GDP per capita rises, and this undoubtedly increases the value of the land. For every US dollar increase, the average distribution of income to the citizen will cause land quality to be increased by about 85 percent. Absolute t-statistic value can be approximated to two, hence validates the statistical significance of the relationship at 10 percent level. Land quality index exhibits strong positive relationship with environmental quality. This is not unexpected as land quality index and environmental quality have some things to do in common. Whatever affects land quality index will have direct and positive effect on the environmental quality. For every increase in the hectares of land for cereal production, there tends to increase in environmental quality as proxy for total greenhouse gas emissions and waste to energy by 77 percent kt of Co2. The absolute t-statistic value can be approximated to two, hence validates the statistical significance of the relationship at 10 percent level.

The coefficient of 0.442422 for trade intensity proxy for trade intensity ratio percentage of gross domestic product is an indication that there is positive but weak relationship between trade intensity and environmental quality. Every percentage increase in the trade intensity will cause land quality to move up by about 44 percent of Kt emissions provided other factors are kept constant. T-statistic value (absolute) is above two threshold, thus validates statistical significance of the relationship at 10 percent level.

Among the considered variables in the model at long run, only urbanization as represented by urban population percentage of total population exhibits negative but strong relationship with environmental quality. Every increase in the urban population tends to over stress the environmental quality and cause it to decline by about 18kt of CO_2 provided other factors are not changed. The absolute t-statistic value is beyond two hence validates the statistical significance of the relationship at 10 percent level.

The coefficient of 0.216905 for capital investment is an indication that there is positive relationship between environmental quality and capital investment. Every percent improvement in the capital investment implies 21 percent increase in the kt of CO_2 for the environmental quality given other factors remains at it were. However, t-statistic value (absolute) is far below two threshold, thus invalidates statistical significance of the relationship at 10 percent level.

If waste-to-energy, fossil energy consumption, gross domestic product per capital, land quality index, trade intensity, urbanization and capital investment are to be all zero, environmental quality will be 43.759 kt of CO_2 as a result of other factors that influence environmental quality but not included in the model. However, the estimate of the t-statistic indicates that the relationship is not significant at 10 percent (See Appendix B).

4.3.3 Economic Implication of the Result

Waste-to-Energy and sustainable development exhibit negative relationship which means to have a robust sustainable development, all effort must be geared towards the way and rate with which waste are turn in to energy. This may not be unconnected to the remnant of the waste that might not be totally converted. The lower the total greenhouse gas emissions as proxy of environmental footprint, the better for sustainable development which by implication means that every unit increase in kt of CO_2 total greenhouse gas emissions as proxy of environmental footprint, sustainable development will shrink by about 17.7 percent. Every improvement in the adjusted net national income is found to be a plus to the sustainable development.

This may be that the government will not be short of fund to embark on projects that have positive impact on the sustainable development. The more measures are put in place to convert all available waste-to-energy, the better the quality of the environment. This is so because all possible dirt would have been taken away hence improving the quality of the environment. Gross domestic product per capita measures the state of average citizen in the economy. The higher the value the better the well-being of an individual. Actions are expected to be tilted towards the improvement in the gross domestic product and to ensure that the population is not growing beyond the resource of the economy.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions of this research study as well as policy recommendations. In line with this, it is divided into four sections summary of findings, conclusion, policy recommendation and suggestions for further studies.

5.1 Summary

Sustainable waste-to-energy development would facilitate effective waste management, supply of alternative clean energy sources to households and/or industries, promote circular economy, socioeconomic prosperity and increase resources efficiency. On the energy side, it supports the National Energy Policy (NEP, 2003) and National Renewable Energy and Energy Efficiency Policy (NREEEP, 2015) approved by Federal Executive Council for energy sector. On the waste side, it also supports the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act of 2007 coupled with the National Environmental (Sanitation and Waste Control) Regulations of 2009 which sets both the institutional and legal frameworks for managing waste in Nigeria. The development of NESREA Extended Producer Responsibility (EPR) guidelines in 2014, which mandates producing companies to be responsible for the lifecycle of their products, also became a key driver, especially in waste processing or recycling.

This study searched into the techno – economic and environmental assessment of waste-to-energy development in Nigeria. Primary data in the form of administered structured questionnaires to relevant stakeholders within the waste management space, expert workshops and interview for key officials in the sector were adopted. Secondary data (1981-2017) were also used to and established the nexus between waste -to- energy, environmental quality and sustainable development within the country. The theoretical framework adopted for the study was Environmental Kuznet Curve (EKC). Descriptive and some inferential analyses were used to examine the spatial variation, challenges and prospects of waste management practices as well as access the cost-benefit of waste-to-energy recovery generation (ReGen) in Nigeria. To further test for the impact of waste-to-energy on environmental quality and sustainable development, Autoregressive distributive lag (ARDL) model was employed where waste-to-energy was a major independent variable on sustainable economic development and environmental quality.

5.2 Conclusions

Waste is a valuable resource and product of the society, and the challenge of managing it sustainably through circular economy technologies cannot be over-emphasized. The appropriate technologies (like waste-to-energy recovery generation) must be climate and environment friendly and cover all the waste management value-chain for an effective community waste management and capacity building. Policies that would facilitate a de-carbonized energy transition and enhance sustainability of waste through circular economy are also required. It is recommended that emphasis should be placed on the following "REDIPODI" to foster effectiveness in circular economy and unlock the potentials in waste as a viable resource;

R-reduce process waste
E-encourage recycling
D-develop markets for recycled materials
I-invest in infrastructure
P-promote reuse
O-optimize lifecycle through alternative consumption
D-design better products
I-improve collection

The study was hinged on the EKC hypothesis that environmental degradation follows an inverted U-shaped trajectory in relation to economic growth. The results of the study confirm the inverted correlation between economic growth and environmental degradation of EKC's hypothesis that at the early stage economic growth increases environmental degradation, then environmental degradation decreases after reaching a certain level of average income per capita. The challenge of environmentally acceptable management of waste is traced to inadequate technical and management skills, as well as limited resources within waste management authorities.

The impact on environmental degradation and health concerns can be reduced by establishing efficient waste processing, disposal, and treatment systems for the expanding volumes of waste. Developing and implementing effective and efficient waste-to-energy in Nigeria requires enhanced social acceptability of waste disposal, handling and treatment as well as improved public information on waste-to-energy as part of waste management. The research work concludes that waste-to-energy has a significant impact on environmental quality and sustainable development.

5.3 Limitations of the Study

The study though a mix of all classes of people, covers the immediate surroundings of major dumpsites and landfills in the six southwestern Nigeria States. Specifically, this research enquiry is limited to the residents, workers and relevant stakeholders in or around the major dumpsites or landfills in Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States located in the Southwest geopolitical zone of Nigeria. However, this limitation concerns only the primary data (objective one); the expert workshops and the secondary data used covers the whole of Nigeria from which conclusion would be drawn.

The study suffered from various limitations such as failure of the waste management organisations to release enough data, and some respondents were reluctant in contributing to the issue researched. Notwithstanding, the outcome of the research was not significantly affected because of longer fieldwork period to ensure that required information sourced with structured questionnaires are effectively filled by all relevant stakeholders in the waste management and energy spaces. A balance was stricken with the mixed methods employed: the primary data were supported with secondary data (1981-2017) and expert workshops.

5.4 Policy Considerations / Recommendations

Successful waste-to-energy development in Nigeria requires good financial investment, information and understanding of future change, knowledge about adaptation options, and the capacity to implement the most suitable interventions nationally. The following policy considerations will address such concerns and will foster sustainable development of waste-to-energy recovery generation in Nigeria and Africa at large.

1. Establish Tech-Funds / Financial Instruments for Waste-to-Energy Recovery Generation

It is worthwhile for governments to consider establishing climate protection and resources conservation technology funds alongside waste management funds to facilitate the promotion of waste-to-energy recovery generation and capacity-based approaches for appropriate climate and environmental friendly technology and manpower development.

2. Incorporate Coping Mechanisms

These coping mechanisms to be incorporated in waste-to-energy recovery generation are based on traditional practices and knowledge, coupled with the right technology transfer or acquisition. The benefit is that the capacity of local people are strengthened to address issues of waste management and energy cum resources recovery within their communities and social structures.

3. Diversify into Circular Economy

From linear to circular economy, there is need of a paradigm shift in the product economy regarding the curtailing of environmental impact and waste of resources through increased efficiency at all stages. In circular economy, better solutions rather than common landfills are proffered to unlock the potentials in waste. Thus, there is need for research studies to unlock the huge potentials and socioeconomic benefits in waste along the whole waste management value chain namely; (a.) Waste Collection Treatment and Disposal; (b.) Waste -to- Resources or Energy Recovery; (c.) Waste Recycling and Composting; and (d.) Waste Source Reduction and Reuse. Governments should put in place policies and programs that promote the 8Rs in waste management which are; Refuse, Reduce, Reuse, Recycle, Recover, Repair, Redesign and Re-engineer.

4. Enforce Polluters' Pay Principle (PPP)

Governments should put their efforts to make the "polluters' pay principle" work more efficiently. Since a larger percentage of people are willing to pay for waste-to-energy recovery generation as part of waste management, creating the right public awareness / education for the enforcement of this polluters' pay principle would be a right step in right direction of effective and profitable or cost-effective sustainable development of waste-to-energy in Nigeria and other African countries.

5. Enforce Sustainable Waste and Energy Recovery Management

Enforcement of sustainable waste and energy recovery management aims at fostering environmental quality, energy recovery generation and sustainable development. Consequently, the socioeconomic and productive capacity of communities – especially those located in or close to waste sources (landfills & dumpsites) would significantly improve and their income base will be increased.

6. Invest in Food-Water-Energy Nexus Research and Development

Since there is a link between food, water and energy production, governments need to invest more on trans/multi-disciplinary research and development that addresses the food-water-energy nexus. The focus being climate protection and resources conservation for food-water-energy security.

7. Adopt Renewables Technology Incentives

It is imperative that governments adopt both fiscal and financial incentives on renewable energy technologies and materials. This would help curb Green House Gases (GHGs) emissions and attract private finance for the expansion of clean energy access and affordability initiatives for all in line with the sustainable development goals (SDGs).

8. Implement Climate Smart Energy Recovery (CSER) Concept

Climate Smart Energy Recovery (CSER) is an interactive approach to address challenges of energy security, waste management, and climate change with some objectives of sustainably increasing environ-socioeconomic productivity to support the following; (I) equitable increases in income, environmental quality, resources recovery, energy security and sustainable development; (II) adapting and building multi-levels resilience of waste management and energy security systems to climate change; (III) eradicating GHGs emissions from resources or energy recovery (including waste-to-resource, waste-to-energy, circular economy, hydrogen economy, renewable energy, etc.) and (IV) transforming towards the de-carbonization of power and process heat supply through efficient renewable energy systems development.

9. Develop and Implement a National Waste-to-Energy Strategy

Government should mandate its relevant Agencies or Ministries to develop and implement a National Waste-to-Energy strategy in collaboration with private sector and professional bodies. It was observed that awareness of WtE is lacking on the part of the government, waste managers and other relevant stakeholders; this is vital for improved sustainable development and environmental quality. Also, by stepping up the number of waste disposal locations or bins, waste management agencies or organizations can enhance the recycling in the value chain. Although waste -to- energy is relatively new (early developmental stage) in Nigeria, this study show it is important to foster sustainable development and better environmental quality. Nigeria like other low-middle income nations, should as a matter of urgency attend to all environmental concerns as increased income improve the environment, and poverty from degradation alleviated. Global environmental concerns advocated for via the sustainable development goals (SDGs) should be taken cognizance of by the Policy Makers. To foster sustainable development and better environmental quality, the need of effective policies, rules, regulation and enforce 'polluters pay principle' that will support waste-to-energy development cannot be over-emphasized. Government should create enabling environment that attracts investors in waste-to-energy recovery generation in Nigeria. Other key recommendations are summarized as follow;

i. **Adequate Funding:** effective waste management practice is "capital intensive", therefore any arm of the government that desires sustainable waste-to-energy (WtE) system should increase her budgetary allocation on waste management and see WtE as an important integral part.

ii. **Adequate Contractual Agreements**: in order to encourage private sector investment into waste-to-energy development in Nigeria, the government must enter into irrevocable long term contractual agreements with the private sector.

iii. **Localized WtE Recovery Generation / Local Technology:** it is important to develop local technology for waste-to-energy recovery generation (ReGen) in Nigeria by "thinking globally but acting locally", this will not only increase the know-how of the locals, it will also alleviate poverty and create more jobs.

iv. **Funding and Development Agencies:** funding and development agencies including both local and international financial institutions should support both the public and private waste-to-energy development initiatives through sustained funding.

v. **Capacity Development and Training:** the introduction of experts' workshops into this study though very expensive and demanding was an eye opener on the imperativeness of capacity development and training for both energy and environment sectors. Since waste-to-energy (WtE) is in its early development stage in Nigeria, various training programs introduced would be a potent tool for sustained effective WtE development and waste management.

5.5 Contributions to Knowledge

There is paucity of empirical research in waste-to-energy development in Nigeria. Most discussion around waste-to-energy have focused more on the general concept of waste management. This study has contributed to knowledge by not just exploring waste-to-energy as an alternative renewable energy source to conventional fossil fueled energy with its dual clean energy/environment benefits, and addition to the national energy mix, it has expanded the knowledge base of both researchers and practitioners in the fields of waste and energy management to a better understanding of the relationship among waste-to -energy, environmental quality and sustainable development.

This study is therefore not just one of the frontiers in the area of investors and users willingness to waste-to-energy projects in Nigeria, it has also exposed stakeholders to much better awareness of the determinants of waste- to energy development success. The waste-to-energy recovery technology (ReGen) with its cost-benefit analysis is also a contribution to the body of knowledge and the waste-to-energy development. A Major contribution to the body of knowledge and waste-to-energy.

5.6 Future Research

Though, this research work found out that waste-to-energy process has significant impact on sustainable development and environmental quality in Nigeria, notwithstanding, it is important that a wider analysis be carried out so as to serve as a germane basis for policy recommendation. More specifically, it is suggested that the primary data analysis such as this is carried out at national level or at other five geopolitical zones of Nigeria. Also, other econometric methods can also be adopted to investigate the technoeconomic and environmental assessment of waste-to-energy development in other countries and at regional (e.g. ECOWAS, etc.) level. With access to enough funds, the construction of a localized waste-to-energy recovery generation (ReGen) in each six geopolitical zones of Nigeria should be a promising research.

REFERENCES

Abdelnaser, C and Gavrilescu, A. S, 2008. Municipal solid waste management in developing countries: A perspective on Vietnam. Vol 35, No 4, 2016.

Abdulai, A. and Ramcke, L. 2009. The Impact of Trade and Economic Growth on the Environment: Revisiting the cross-country evidence. Kiel Working Paper: Kiel Institute for Working Economy, No. 1491, 2009.

Adekomaya O, and Ojo, K 2016. Adaptation of plastic waste to energy development in Lagos: An overview assessment, Vol 35, No 4, 2016.

Adekunle, A. A. and Adeniyi, A. O. 2015. Hydrocarbon utilization of fungi isolated from Treculia africana (Decene) seeds. African journal of environmental science and technology. 9(2):126-135.

Adekunle, I. M., Adebola, A. A., Aderonke, K. A., Pius, O. A., Toyin, A. A. 2011. Recycling of organic wastes through composting for land applications: A Nigerian experience. Waste Mgt. Res., 29(6): 582 – 93.

Adesanya, Y.O. 1986. Constraints to Solid Waste Management: A Case Study of Ibadan. An unpublished MURP Degree Dissertation. University of Ibadan.

Adewole, A. T. 2009. Waste management towards sustainable development in Nigeria: A case study of Lagos state. International NGO Journal, Vol. 4, 173-179.

African Development Bank 1996. The Electricity Sub-Sector in Africa. African Energy Programme. Energy Sector Technical Paper Series Paper No. ES1. ADB Abidjan.

Agunwamba, J., 1998. Solid Waste Management in Nigeria: Problems and Issues, Environ. Mgt. 22, 849 – 856

Ahmed, Y. A. 2016. Potential impacts of climate change on waste management in Ilorin city Nigeria. Global Journal of Human Social Science, 12(6): 39 - 48.

Ajero, C.M.U and Chigbo, U.N 2006. A study on the evaluation of industrial solid waste management approaches in some industries in Aba, Southeastern Nigeria.

Akhator, E. P; Obanor, A. I; Igbinomwanhia. D. I., 2016. Thermal analysis of a small scale solid waste-fired steam boiler for power generation in Benin City, Nigeria. Nigerian Journal of Technology, 35 (3): 551 – 561.

Akhator, E. P; Obanor, A. I; Ezemonye, L. I, 2016. Electricity generation in Nigeria from municipal solid waste using the Swedish waste-to-energy model. J. Appl. Sci. Environ. Manage. Vol. 20 (3) 635 – 643. JASEM ISSN 1119 – 8362.

Akinbode, A. 2002. Introductory Environmental Resources Management. Ibadan: Daybis Publishers.

Akinwale, A. 2004. The potential for climate change mitigation in the Nigerian solid waste disposal sector.

Akomolafe, K. J., Danladi, J. D. and Oseni, Y. R. 2015. Trade Openness, Economic Growth, and Environmental Concern in Nigeria.International Journal of African and Asian Studies, Vol. 13.

Akpan, U. F. and Chuku, A. 2011. Economic Growth and Environmental Degradation in Nigeria: Beyond the Environmental Kuznets Curve. Munich Personal RePEc Archive (MPRA), Paper No. 31241. Available online athttp://mpra.ub.uni-muenchen.de/31241/

Amusan O. A, 2023. Analysis of Waste-to-Energy, Environmental Quality and Sustainable Development Nexus in Nigeria (IAEE 2023 & Elsevier 2023 Under Review).

Amusan, O. A. 2022. Impact Assessment of Waste-to-Resources Management for Circular Economy Development and Green Growth in Nigeria and Ghana. Tropentag Prague, Czech Republic 2022.
Open Access ID - 478.

Amusan, O. A. 2022. Environmental Assessment of Waste Management in Urban Cities of Southwestern Nigeria for Circular Economy Development and Green Growth. NAEE/IAEE Conference Publication, Abuja, Nigeria.

Amusan, O. A. 2022. Waste Management and Green Energy Recovery in Nigeria: The Problem, Practice, Perception and Prospect. NAEE / IAEE Conference Publication, Abuja, Nigeria.

Amusan, O. A. 2021. Evaluation of Waste-to-Energy Theory of Change and Sustainable Development Goals Realisation in Ghana Low - Income Communities. NAEE/IAEE Conference Publication, Abuja, Nigeria.

Amusan, O. A. 2020. Evaluating the Relationship between Solid-Food Waste, Environment and Economic Security among Malnutrition in Nigeria. Tropentag Hohenheim 2020, Germany. Open Access ID - 184.

Amusan, O. A. 2019. Unlocking the Potential in Waste through Circular Economy. Association of Waste Managers of Nigeria (AWAMN) Award Paper. AWAMN Waste Management Industry Publication 1: 31-37.

Amusan O. A, 2019. Engineering the Energy Transition with Waste-to-Energy System that Links the Environment, Economic & Social Components of SDGs. NAEE/IAEE Conference Publication, Abuja

Amusan O. A, 2018. Renewable Energy Recovery Generation for Security and Safety in Global Agriculture and Production: Justification and Outlook (Tropentag Ghent Belgium 2019 Conference Publication).

Amusan, O. A. 2018. Sustainable Agri-Value Chain and Production: Interplay of Efficient Resource Use and Energy Systems in World's Remote Areas. FOOD2030 Hohenheim, Germany. Online Paper ID - A159.

Amusan O. A, 2016. Benefits of Irrigation among Smallholder Farmers in the South-western Nigeria. Lambert Academic Publishing – ISBN-978-3-8473-3564-1, 2016.

Amusan, O. A, 2015. Fostering food security and mitigating food wastage through quality management practices in cocoa production. Institute of Nutrition – International Future Food Conference Potsdam.

Anekwe, R. 2016. Waste management and sustainable development in Nigeria: A study of Anambra State waste management agency. European Journal of Business & Management. ISSN 2222-1905.

Article (PDF Available) in Environmental engineering and management journal 7(4):469-478 · July 2008 with 3,247 Reads.

Asuquo, A. I., Kinuabeye, J. U. and Atu, J. E. 2012. "Attitude of urban dwellers of waste disposal and management in calabar, european journal of sustainable development vol 1, no. 1, pp 22-34.

Attah, M. 2013. Problems of domestic waste management in Nigeria: any repressors? University of Benin: faculty of law.

Attah, M. 2013. Problems of domestic waste management in Nigeria: any repressors? University of Benin: faculty of law. Bridgewater, A.K. (1980). Waste management in Europe van stand Reinhold at Ltd England.

Babayemi, J. O., Dauda, K. T. 2009. Evaluation of solid waste generation, categories and disposal options in developing countries: A case study of Nigeria. J. Appl. Sci. Environ. Management. 13(3):83- 88.

Barro, 1990. "Government Spending in a Simple Model of Endogenous Growth," Journal of Political Economy, October 1990, 98, S103–S125.

Bartone, C. 1991. The Environmental Challenges of Third World Cities. APA Journal, 5 (44)

Baserga, U. 2000. Vergaerung Organischer Reststoffe in Landwirtschaftlichen Biogasanlagen, FAT Bericht Nr. 5. Eidgenoessiche Forschungsansalt fuer Agrarwirtschaft and Landtechnik.

Beatrice A. and Jussi K. 2013. Municipal Solid Waste Management Problems in Nigeria: Evolving knowledge management solution. International Journal of Environmental and Ecological Engineering. Vol. 7, No: 6.

Bingemer, H.Q., Crutzen, P.J., 1987. Production of methane from solid waste. Journal of Geophysical Research 87 (D2), 2181–2187.

Boye, T. E., Nwaoha, T. C., Olusegun, S. D., and Ashiedu, F.I., 2017, A Validation Method of Computational Fluid Dynamics Simulation against Experimental Data of Transient Flow In Pipes System, American Journal of Engineering Research (AJER), 6(6), pp.67–79.

Bridgewater, A.K. 1980. Waste management in Europe van stand Reinhold @ Ltd England.

Buckets C. and Smith, D. 1994. Introduction to Solid Waste Management, www.plastic.ca/epic

Burda, M. and Wyplosz, C., 2002. Macroeconomics – A European Text, Third Edition, Oxford University Press, Oxford.

Butu, A. W. and Mshelia, S. S. 2014. "Municipal solid waste disposal and environmental issues in Kano metropolis Nigeria"; Britain Journal of Environmental Sciences vol.2, no.1, pp1-16, June 2014. Published by European centre for research training and development UK (www.eajournals.org).

CBN 2006. Central Bank of Nigeria Statistical Bulletin. CBN Press, Abuja.

CDM 2016. CDM-Executive Board. Project Design Document, Salvador da Bahia Landfill Gas Management Project. Version 8.2. [Online]. Available: http://cdm.unfccc.int/Projects

CDM 2012. CDM-Executive Board, Project Design Document CEMEX Mexico: Biomass Project at Huichapan Cement Plant, Version 3, 2012.

CEMBUREAU 2015. Activity Report of the European Cement Association, Brussels.

Challenges with reference citations among postgraduate students at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Chattopadhyay, S., Dutta, A., Ray, S., 2009. Municipal Solid Waste Management in Kolkata, India – A Review, Waste Management Vol. 29, 1449 – 1458.

Chieke T. C, Igworo E. C 2008. Urban and Rural Electrification: Enhancing the Energy Sector in Nigeria using photovoltaic technology. African Journal Science and Tech. 9(1): 102-108.

Chukwu, A. O. 2002. The Effect of Indiscriminate Disposal of Plastic Waste in the Environment: A Case study of Enugu. An unpublished BURP Dissertation of Department of Urban and Regional Planning, University of Nigeria.

Cointreau-Levine, S., 1994. Private sector participation in municipal solid waste management service in developing countries. Vol. 1. The formal sector – UNDP/UNCHS/ The World Bank – Urban Management Programme. pp. 52.

Cointreau, S. 1995. Private sector participation in municipal solid waste service in developing country. Volume 1 Formal Sector. Washington D.C. Urban Sector Board of World Bank. Avaiable at: http://wwwwds. worldbank.org.

Council for Renewable Energy, Nigeria (CREN) 2009. Nigeria Electricity Crunch. Available at www.renewablenigeria.org

CWG 2016. Collaborative Working Group on Solid Waste Management in Low and Middle Income Countries. CWG Rapid Technology Assessment Tool.

Department of Petroleum Resources (DPR) 2007. Nigeria. Available at http://www.DPR.gov.ng

Diji, C. J.; Ekpo, D. D; Adadu, C. A. 2013. Design of a Biomass Power Plant for a Major Commercial Cluster in Ibadan, Nigeria. The International Journal of Engineering and Science (IJES), Vol. 2. Issue No. 4, pp. 23 – 29. ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805. www.theijes.com

Dizaji, M., Badri, A. K. and Shafaei, M. 2016. Investigate the Relationship between Economic Growth and Environmental Quality in D8 Member Countries. The Journal of Middle East and North Africa Sciences, Vol. 2, No. 5, pp. 1 – 7. http://www.jomenas.org

Dugard, J. 'International Human Rights' in Van Wyk, et.al Rights & Constitutionalism, 177.

EAWAG, Sandec 2008. Global Waste Challenge, Situation in Developing Countries. Swiss Federal Institute of Aquatic Science and Technology. Sandec, Deebendorf.

Ebikapade, J. Amasuomo A. and Jim B. 2017. Solid waste management trends in Nigeria. Journal of Management and Sustainability, Vol. 6, No. 4; 2016.

Ecofys 2010. The Ecofys Energy Scenario, December 2010.

Eckrohrkessel 2018. Handbook of Waste-to-Energy and Power Systems. Berlin, Germany.

Ellen MacArthur Foundation 2013. Towards the Circular Economy, Opportunities for the Consumer Goods Sector.

Emeka E. E 2010. Causality Analysis of Nigerian Electricity Consumption and Economic Growth. Journal of Economics and Engineering. 4: 80-85, ISSN: 2078-0346.

Energy Commission of Nigeria (ECN) 2005. Renewable Energy Master Plan.

Energy Commission of Nigeria (ECN) 2007. Draft National Energy Masterplan.

Energy Commission of Nigeria 2008. National Energy Policy. Federal Republic of Nigeria, Abuja.

Englande A. J., Guang J., 2006. "Application of biotechnology in waste management for sustainable development: An overview", Management of Environmental Quality: An International Journal. Vol. 17 Issue: 4, pp. 467-477, http://doi.org/10.1108/14777830610670526

EPA 2016. EPA, LFG Energy Projects, Frequently Asked Questions. www3.epa.gov/mop/faq/lfg.html

EU 2010. Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial Emissions (Integrated Pollution Prevention and Controls). EUR – Lex Brussels.

EU 2006. Integrated Pollution Prevention and Control, Reference Document on the Best Available Techniques for Waste Incineration. European Commission, Brussels.

EU 2003. Refuse Derived Fuel, Current Practice and Perspectives (B4-3040/2000/306517/MAR/E3) WRc Ref: CO5087-4, European Commission, Brussels.

Etukudor, C. et al, 2015. The Daunting Challenges of the Nigerian Electricity Supply Industry, Journal of Energy Technologies and Policy. Vol. 5, No. 9. 25 – 32 www.iiste.org

Eurostat, 2016. Each Person in the EU Generated 475kg of Municipal Waste in 2014, 22.03.16.

Eurostat 2016. Electricity price statistics. Available atwww.ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics#Electricity_prices_for_household_consumers. (Accessed on June/2/2016).

Eurostat, 2012. Generation and Treatment of Municipal Waste (1000 t) by NUTS 2 Regions.

Eze, H. O and Asoadu, E. C 2003. Sustainable Solid Waste Management in Enugu. A Paper Presented at the 34th Annual Conference of the Nigeria Institute of Town Planners, Abeokuta, 22-24/10/2003.

Fachverband 2016. Fachverband Biogas, Bio-waste to Biogas. Freising. [Online] Available: http://www.biowaste-to-biogas.com/

F.H.W 2002. Case Study Thermo Select Facility Karlsruhe. TNO Environment, Energy and Process Innovation, the Netherlands.

Fulli, G. 2016. Electricity Security Models and Methods for Supporting the Policy Decision Making in the European Union. Doctoral Thesis presented to Politecnico Di Torino, Turin-26th April, 2016 pp.59.

Gibba, P., Sylla. M., and Okogbue. Characterization and Projection of Extreme Precipitation Events over Africa. WASCAL Publication sponsored by German Ministry of Education and Research (BMBF) through the University of Bonn, Germany.

GIZ 2017. A Guide for Decision Makers in Developing and Emerging Countries. WtE in MSWM.

GIZ 2015. Guideline, Application of Waste-to-Energy in Vietnam.

Glenn Whitefield, 2012. The Importance of Proper Definition www.piadvice.wordpress.com accessed on 19/09/2018.

Global News Wire, 2015. Waste to Energy Market Will Be Worth $37.64 Billion by 2020.

Goff, S., Norton, J and Castaldi, M. 2013. Webinar: Turning Trash into Renewable Energy Treasure, America Society of Mechanical Engineers.

Graziano, A. and Matteo, F. 2010. The environmental kuznets curve in the municipal solid waste sector. Higer education research on mobility regulation and the economics of local services.

Graziano, P. 2007. Adapting to the European Employment Strategy? Recent Developments in Italian Employment Policy, in International Journal of Labour Law and Industrial Relations, 4: 543-565.

Green Investment Bank 2014. The United Kingdom Residual Waste Market.

Greppi, E. 1994. European Investment Bank and the Financing of Municipal Waste Disposal. Luxemburg: European Investment Bank.

Guerrero, L. A., Mass, G., Hogland, W., 2013. Solid waste management challenges for cities in European developing countries. Waste Manage, 33, 220-232 http://dx.doi.org/10.1016j.wasman.2012.09.008

Gupta, S., Mohan, K., Prasad, R., Gupta, S., Kansal, A., 1998. Solid Waste Management in India: Options and opportunities, Resour. Conserv. Recycling 24, 137-154.

Haberl H. 2006.Global Socioeconomic Energetic Metabolism as a Sustainability Problem. Energy 33: 842-857.

Hazra, T., Goel, S., 2009. Solid waste management in Kolkata, India: practices and challenges. Journal of Waste Management 29, 470–478.

Henry, R. K., Yongsheng, Z., Jun, D., 2006. Municipal solid waste management challenges in developing countries – Kenyan case study. Journal of Waste Management 26, 92–100.

Higman, C. and Burgt, M. 2011. Gasification, Gulf Professional Publishing.

Hoornweg, D. and Bhada-Tata, P 2012. What a Waste: A Global Review of Solid Waste Management. Urban Development Series; Knowledge Papers No. 15 World Bank, Washington, D.C.

IEA 2009. International Energy Agency (IAE), World Energy Outlook (WEO) Paris 2009.

IEA 2010. International Energy Agency (IAE), World Energy Outlook (WEO) Paris 2010.

Isaac, I. M. and Olamike, S. 2007. Waste management in emerging cities, any solution? Aba: Great Ventures Ltd.

Iwayemi, A. 1983. Energy in West Africa, Energy Policy, September, 235-249.

Iwayemi, Akin 2011. Energy Sector Development in Africa. Research-Gate. https://www.researchgate.net/publication/2289017

Igbinomwanhia, D. I 2012. Characterization of Commercial Solid Waste in Benin Metropolis, Nigeria. Journal of Emerging Trends in Engineering and Applied Sciences, 3(5):834 - 838.

Ighodaro CAU 2010. Co-integration and causality relationship between energy consumption and Kuznets curve analysis approach. Journal of Economics and Finance. 7(4), pp.72-79.

Ighodaro CAU 2010. Co-integration and causality relationship between energy consumption and eeconomic growth: Further empirical evidence for Nigeria. Journal of Business Economics and Management. 11 (1): 97-111.

Jimoh, I. A 2005. Jimoh, I. A. 2005. A new approach to Municipal Waste Management in Nigeria. International Conference on Energy, Environment and Disaster.

Kadafa, A. A, Latifah C, AbdManaf G, Abdullah O, Ho S, Sulaiman P, Wan N, 2013. Current Status of Municipal Solid Waste Management Practice in FCT Abuja, Research Journal of Environmental and Earth Sciences, 5(6):295-304.

Kalyani, K. A., Pandey, K. K., 2014. Waste to Energy Status in India: A Short Review, Renewable and Sustainable Energy Reviews, Vol. 31, 113-120.

Kanagawa, M and Nakata, T. 2007. Analysis of the energy access improvement and its socio-economic impacts in rural areas of developing countries. Ecological Economics, 62(2): 319-329.

Karekezi, S. and Ranja T. 1997. Renewable Energy Technologies in Africa. AFREPEN. Nairobi. Zed Press. London.

Lim, E. C., and Alum, J. 1995. Construction productivity: issues encountered by contractors in Singapore. International Journal of Project Management, 13(1), 51-58.

Lior N 2008. Energy Resources and Use: The Present Situation and Possible Path to the Future. Energy 33: 842 - 857.

Longe, E., Longe, O., and Ukpebor, E. 2009. People's Perception on Household Solid Waste Management in Ojo Local Government Area, In Nigeria. Iranian Journal of Environmental Health Science & Engineering, 6, 209-216.

Lucas, Robert E., 1988. "On the Mechanics of Economic Development," Journal of Monetary Economics, 1988, 22 (1), 3–42.

Managing the Unwanted Materials: The Agony of Solid Waste - Online.

Manfredi, S. and Christensen, T. H. 2009: Environmental assessment of solid waste landfilling technologies by means of LCA-modeling. Waste Management 29, 32-43.

Mavropoulos, A, Wilson, D, Velis, C, Cooper, J and Appelqvist, B, 2012. Globalization and Waste Management. Phase 1: Concepts and Facts. International Solid Waste Association, Wien.

Modebe, I. A., Onyeonoro, U. U., Ezeama, N. N, Ogbuagu, C.N.O and Agam N. E. 2008. Public health implication of household solid waste management in Awka Southeast Nigeria. The Internet Journal of Public Health; 1(1); 78-91.

Mowoe, K. M 1990. Quality of life and Environmental Pollution and Protection. In Faculty of Law, University of Lagos, Environmental Law in Nigeria (p.177).

Muhammad N. O. and Oloyede, O. B. 2009. Haematological parameters of broiler chicks fed Aspergillus University of Lagos, Environmental Law in Nigeria (p.177).

Muhammad N. O. and Oloyede, O. B. 2009. Haematological parameters of Broiler chicks fed Aspergillus Niger fermented terminalia catappa seed meal-based diet. Global Journal of Biotechnology and Biochemistry 4(2): 179-183.

Municipal solid waste management challenges in developing countries – Kenyan case study.

Murad, M.W. and Siwar C. 2007. Waste management and recycling practices of the urban poor: a case study in Kuala Lumpur city Malaysia. Waste Manage Res. 25(1); 3-13.

Naji C et al 2010. In: Nnaji CE, Uzoma CC (eds) CIA World Factbook, Nigeria, http://www.cia.gov/library/publications/the-world-factbook/goes/ni

Narayana, T., 2009. Municipal solid waste management in India: From waste disposal to recovery of study in Kuala Lumpur City Malaysia. Waste Manage Res. 25(1); 3-13.

National Bureau of statistics (NBS) 2007. National Core Welfare Indicator Questionnaire (CWIQ) survey: NBS, Abuja, p2, Summary Sheet.

National Research Council 1993. Demographic Effects of Economic Reversals in Sub-Saharan Africa. National Academy Press. Washington DC.

New Economy, MGC. 2015. Cashability Discussion Paper, Version Number 1.

Newman, D. G; Lavelle, J. P and Eschenbach, T. G 2000. Engineering Economic Analysis, 8th Edition ISBN 1 – 57645 – 053 -8.

Nikiema, P., Sylla. M., and Ogunjobi, K. Uncertainties in Global and Regional Climate Change Projection of Summer Monsoon Temperature and Precipitation over West Africa. WASCAL Publication sponsored by German Ministry of Education and Research (BMBF).

Nixon, J. D., Dey, P. X. and Ghosh, S. K. 2017. Energy Recovery from Waste in India: An Evidence-Based Analysis. Elsevier.

Nnodim, O. 2016. Power generation crashes to 1,400MW. Punch Newspaper, 18 May. Available at http://www.punchng.com/powergenerationcrashes1400mwtcn/ (7th June, 2016).

Nwachukwu, M. U. 2010. Solid Waste Generation and Disposal in a Nigerian City: An Empirical Analysis in Onitsha Metropolis. Journal of Environmental Management and Safety. (JEMS). Vol. 1, No. 1, Pp. 180-191.

Oberai, A. S. 1987. Migration, Urbanization and Development. ILO. Geneva.

Ochelle, F. O. 2015. Nigeria's power generation is now 4,600 megawatts: will this speed up the impending electricity tariff hike? Ventures Africa, 7th June. Available at http://venturesafrica.com/powergenerationnigerianow4660megawattswillthisspeeduptheimpendingelectricitytariffhike/

Odunola O. A., Akinwumi K. A., Ogunbiyi B., Tugbobo O. 2015. Interaction and enhancement of the toxic effects of sodium arsenite and lead acetate in wistar rats. African Journal of Biomedical Research. 2007; 10(1):59–65. doi: 10.4314/ajbr.v10i1.48972.

Ogbalu, A. I 2004. Refuse Management: The Role of Health Education. Environmental Studies and Research Journal, Vol. 2, Pp. 41 – 53.

Ogboi K. C and Okosun, A. E 2003. The Role of Scavengers in Urban Solid Waste Management in Nigeria. Environmental Studies and Research Journal. Vol. 2, Pp. 85 – 92.

Ogboru, I. &Anga, R. A. 2015. Environmental Degradation and Sustainable Economic Development in Nigeria: A Theoretical Approach. Research journal of Economics, Vol. 3, No. 6, pp. 1 – 13.

Ogwueleka T. C., 2003. Analysis of urban solid waste in Nsukka, Nigeria. Journal of Solid Waste Nigeria: Technology and Management, 29 (4): 239-246.

Ogwueleka T. C., 2004. Planning model for refuse management. Journal of Science &Technology, 3(2): 71-76.

Ogwueleka T. C., 2009. Municipal Solid Waste Characteristics and Management in Nigeria. Iran Journal of Environmental Health Science and Engineering. Vol. 6, No. 3, pp. 173-180.

Ohunakin O. S 2010. Energy Utilization and Renewable Energy Sources in Nigeria. Journal of Engineering and Applied Sciences 5(2): 171-177.

Okafor ECN and Joe-Uzuegbu CKA 2010. Challenges to Development Of Renewable Energy For Electric power sector in Nigeria. International Journal of Academic Research 2(2): 211-216.

Okpala, D. C. 1986. Institutional Problems in the Management of Nigerian Environment. NISER Research Monograph Series Ibadan.

Oladele, M. B. 2011. Impact of recycling on environmental quality and revenue generation in University of Lagos.

Oladepo O. W, Taiwo A and Ilori M. O. 2010. Environmental policy implications of packaging waste disposal practices in Nigerian food sector Vol. 2(1), pp. 039-046.

Olalere, O. A., Abdurahman, N. H. and Alara, O. R., 2017. Extraction, radical scavenging activities and physicochemical fingerprints of black pepper (Piper nigrum) extract. Journal of Food Measurement and Characterization.

Olaniyan, O. S., Ige, J. A and Akeredolu, D. A. 2015. Solid waste management of Omi-Adi, Ibadan, Oyo State, Nigeria. International Journal of Research in Engr. & Tech, 3(2), 21-25.

Oluwade, D. A. 1993. A Guide to Tropical Environment Health and Engineering. NISER Monograph Series Ibadan.

Omirin, M. M. and Osagie, J. U 2011. Outsourcing for sustainable waste disposal in Lagos metropolis: Case study of Agege Local Government, Lagos Review on the Environmental Impacts of Municipal.

Omojolaibi, J. A. 2009. A Comparative Study of Carbon Emissions and Economic Growth: Analysis of Panel Data. Journal of Management and Entrepreneur, I (2), 101-113.

Omojolaibi, J. A. 2010. Environmental quality and economic growth in some selected west African countries: A panel data assessment of the environmental kuznets curve. Journal of Sustainable Development in Africa (Vol. 12, No. 8, 2010) ISSN: 1520-5509.

Omole, F. K and Alakinde, M. K, Department of Urban and Regional Planning, Federal University of Technology, P.M.B 704 Akure, Nigeria.

Onwughara, I. N., Nnorom, I. C., and Kanno, O. C. 2010. Issues of roadside disposal habit of municipal solid waste, environmental impacts and implementation of sound management practices in the developing country Nigeria. International Journal of Environmental Science and Development, 1(5): 409 - 418.

OPEC REVIEW. 1993. Energy Development and Sub-Saharan Economies in a Global Perspective. Spring, 29-45.

O'Toole, L. L., Schiffman, J. R., and Edwards, M. L. K. 2007. Gender violence: Interdisciplinary perspectives. New York: New York University Press.

Oyedepo, S.O, 2012, ‘Efficient energy utilization as a tool for sustainable development in Nigeria’ International Journal of Energy and Environmental Engineering, 3:11, Pp. 1-12.

Oyediran O., 1997. Enhancing Environmental Protection in Nigeria through Environmental Education. A paper presented at the International Seminar on the Petroleum Industry in Nigeria. Sustainable Options. Environmental Studies and Research Journal, Vol. 3 Pp. 57 – 65.

Oyeniyi, B. A 2011. Waste Management in Contemporary Nigeria: The Abuja Example. International Journal of Politics and Good Governance, 2(2.2).

Oyeshola K. 2007, Recovery and recycling practices in municipal solid waste management in Lagos, Nigeria Article in Waste Management · February 2007 DOI: 10.1016/j.wasman.2006.05.006 · Source: PubMed.

Phimphanthavong, H. 2013. The Impacts of Economic Growth on Environmental Conditions in Laos International Journal of Business Management & Economic Research. 4(5), pp. 766-774.

Proposal for New Waste Management System in Nigeria Environmental Costs of Exploiting Solid Minerals in Nigeria, Journal of Geography, Environment and Earth Science International 8(1): 1-12, Article no. JGEESI.26855 ISSN: 2454-7352.

Rai GD 2004. Non – Conventional Energy Sources. Khanna Publishers, Delhi.

Ramchandra P, Boucar D 2011. Green Energy &Technology. Springer, London Dordrecht Heidelberg New York.

Romer F. and Paul M., "Crazy Explanations for the Productivity Slowdown," in Stanley Fis- cher, ed., NBER Macroeconomics Annual 1987, Cambridge, MA: MIT Press, 1987.

Rotich K. Henry, Zhao Yongsheng, Dong Jun College of Environment and Resources, Jilin University, Changchun 130026, China, Accepted 4 March 2005, Available online 11 July 2005.

Rapport, J., Zhang, R., Jenkins, B. M and Williams, R. B 2008. Current anaerobic digestion technologies used for treatment of municipal organic solid waste. California Environmental Protection Agency.

Rumsey, S. 2008. How to find Information: A Guide to Researchers. In S. Rumsey, How to find Journal Information: A Guide to Researchers (p. 78). England: Open University Press.

Sambo, A. et al. 2010. Electricity Generation and the Present Challenges in the Nigerian Power Sector, Research Gate, Berlin, 1 – 17.

Sami B. N. and Mohammed O. 2011. Emerging Markets Review, 2011, Vol. 12, Issue 1, 1-20.

Secretariat of the Basel Convention, Basel 2012. Technical guidelines on the environmentally sound co-processing of hazardous waste in cement kilns.

Singh, R. P., Tyagi, V. V., Allen, T., Ibrahim, M. H and Kothari, R., 2011. An overview for exploring the possibilities of energy generation from municipal solid waste (MSW) in Indian scenario. Renewable and Sustainable Energy Review 15, 4797 – 4808.

Sokona, Y; Mulugetta, Y; Gujba, H 2012. Widening energy access in Africa: Towards energy transition. Energy Policy, 47 (1): 3 – 10.

Srivastava, P. K., Kulshreshtha, K., Mohanty, C.S., Pushpangadan, P., and Singh, A., 2005. Stakeholder-based SWOT analysis for successful municipal solid waste energy in Lucknow, India, Waste Management. 25, 531 – 537.

Starr R. M. 2003. Economic 200B - Microeconomic Theory Markets and Welfare. University of California, San Diego, the United States of America.

Stein K, et al. 2002. Interactions of Pex7p and Pex18p/Pex21p with the peroxisomal docking machinery: implications for the first steps in PTS2 protein import. Mol Cell Biol 22(17): 6056-69.

Sule, R. O. 2001. Urban environmental pollution, a critical assessment: a synopsis published by Baaj international company, Ibadan/Benin.

Suzumura K,, Arrow K., and Sen A. 2001. Introduction Handbook of Social Choice and Welfare. Amsterdam: Elsevier / North-Holland. October 2001.

Tariwari C, Angaye N. and Jasper F., Abowei N. 2017. Solid Waste in Nigeria: Challenges and Prospects Article (DOI: http://doi.org/10.15580/GJEMPS.2017.2.062117079).

Thaddeus, C. N and Onyanta, A. 2013. Improved Recycling Performance: Policy options for Nigerian cities. Nordiska Afrikainstitutet.

The Nigeria's SAIDI/SAIFI Dichotomy was extremely high and totally unacceptable when respectively compared with internationally acceptable standards of 90-180 minutes duration of one interruption and 1-2 frequency of interruptions.

Tsai, W. T., Chou, Y. H., 2006. An Overview of Renewable Energy Utilization form Municipal Solid waste (MSW) incineration in Taiwan. Renewable and Sustainable Energy Reviews 10, 491-502. 2004.09.006.

Ubani, O. J. 2003. Municipal Waste Generation and Management in Nigeria. Sustainable Options. Environmental Studies and Research Journal, Vol. 3 Pp. 57 - 65.

Uchendu, C. 2008. Municipal solid waste treatment and recycling technologies for developing countries: Typical Nigeria Case Study. Journal of Solid Waste Treatment and Management, 34: 127-135.

Ugwunwa, F. A. 2005. Indiscriminate Disposal of Solid Waste in Urban Environment: Cause and consequences: A case of Onitsha metropolis. Unpublished BURP Degree Dissertation of Department of Urban and Regional Planning. University of Nigeria.

UNEP 1996. World Resources 1996 – 97. The Urban Environment UNEP New York, USA.

UNFCCC 2016. United Nation Framework Convention on Climate Change. [Online]. Available: http://cdm.unfccc.int/Projects/projsearch.html

United Nations, Department of Economic and Social Affairs, Population Division 2014. World Urbanization Prospects: The 2014 Revision, Highlights, United Nations, New York.

………..... 2013. Sustainable Development Challenges. United Nations, New York.

…………. 1980. Patterns of Urban and Rural Population Growth. United Nations, New York.

United Nations latest estimate. (15/09/2018). MANAGINGYPERLINK Decoding" http://www.worldometers.info/nigeriapopulations www.worldometers.info/nigeriapopulation

Voegeli, Y., Lohri, C. R., Gallardo, A., Diener, S., and Zurbuegg, C. Anaerobic digestion of bio-waste in developing countries. EAWAG, Duebendorf.

Wang-Yao, K., Towprayoon, S., Chiemchaisri, C., Gheewala, S. H and Nopharatana, A 2006. Seasonal variation of landfill methane emissions from seven solid waste disposal sites in central Thailand. Presented in 2nd Joint International Conference on Sustainable Energy and Environment, Bangkok.

WBCSD 2014. World Business Council for Sustainable Development. Guidelines for co-processing fuels and raw materials in cement manufacturing.

WEC 2016. World Energy Council (WEC), World Energy Resources (WER) 2016.

Wellinger, A., Murphy, J. D. and Baxer, D., 2013. The Biogas Handbook. Science, Production and Applications. Cambridge: Woodhead Publishing.

Whyte, R and Pery G 2001. A Rough Guide to Anaerobic Digestion Costs and MSW Diversion. Renewable Energy.

Wilson, D. C, Rodic, L, Modak, P, Soos, R, Carpintero, A, Velis, C, Iyer, M and Simonett, O. 2015. Global waste management outlook. United Nations Environmental Program and International Solid Waste Association, Osaka and Wien.

Wolde, E. T. 2015. Economic growth and environmental degradation in Ethiopia: An environmental Kuznets curve analysis approach. Journal of Economics and Finance. 7(4), pp.72-79.

World Bank 1999. Municipal solid waste incineration. The International Bank for Reconstruction and Development, Washington, D.C.

World Bank 1997. African Development Indicators.

World Bank 1997. World Development Report.

World Bank, 1992. World Development Report, Development & Environment, New York. Paper No 13.

WWF 2013. World Wide Fund for Nature, the Energy Report Summary, Switzerland 2013.

www.dengineering.de [Online]. Available: http://www.dengineering.de/images/Fliessbild-Pyrolyse- D -1.jpg

Yang, T and Yuan, J and Sun 2007. "Rate Optimization for IDMA Systems with Iterative Multi-user Decoding" IEEE Globecom 2007.

Yuanyuan 2015. Chinese Waste-to-Energy Market Experiences Rapid Growth, REW, 28.04.17.

Zhuang, J., Gentry, R.W., Yu, G., Sayler, G.S., Bickham, J.W., 2010. Bioenergy sustainability in China: potential and impacts. Environ. Manage. 46, 525 – 530.

APPENDIX A

2.4: Summary of Theoretical and Empirical Review

Table 2.1 Theoretical & Empirical Review (Source: Author's Compilation).

S/N	NAME	STUDIES	SCOPE / PERIOD	METHOD – OLOGY	VARIABLE OF INTEREST	THEORETICAL FRAMEWORK	EMPIRICAL RESULTS
1	Timiebi (2017)	The State of Solid Waste Management in Port Harcourt City, Nigeria	Nigeria / 2017	Descriptive Statistics and Secondary data from books, journal articles and web pages of specific organizations, and personal study area knowledge were utilized. Landfill, open dumps	Waste composition, Food waste, Paper, plastic, glass, metal	Theoretical gas yield	The study established that, wastes are often burned as well as disposed of on landfills, open dumps and water bodies without necessary prior treatment. It concluded with some recommendations that can improve the waste management situation of the city.
2	Aboyade (2004)	The Potential for Climate Change Mitigation in the Nigerian Solid Waste	Sweden / 2004	Adapted from the theoretical gas yield and kinetic methodology (Scholl-Canyon	Estimates of degradable organic carbon content of the waste, and the disposal site	Export-led growth theory	The findings show that no electricity is generated from recovered methane, and all the recovered gas

				Model).	quality management were the variables considered.		was flared.
3	Gana and Dauda (2014)	An Investigation into Waste Management Practices in Nigeria	Nigeria / 2014	Primary and secondary sources statistical analysis method Chi-square Phyllis Recycling Pulverization Hog Feeding Incineration Composting	Plastics, rubbers, textile, paper materials, food packaging, leather, mental canes, glass, and wood Materials.	Classical theory	They found that FEPA service strategies are effective and efficient because they are accessible to existing change resulting into standard waste management basic hygiene in Nigerian Cities.
4	Anna ad Anna, (2016)	Analysis of greenhouse gas emission	European Union	Agglomeration algorithm (Taxonomic methods).	Energy, Mineral resources, greenhouse gas emission	Theory of multivariate distributions	The finding shows that cluster 3 which Germany belongs has the highest CO_2, NO_x and NO_2.
5	Rodríguez (2011)	Cost Benefit Analysis (CBA) of a Waste to Energy Plant for Montevideo	Montevideo, Uruguay	Cost-Benefit Analysis	Waste generation, GDP per capita	Life cycle assessment theory	The findings so that the proposed WTE with a new landfill would require a lower investment and, during the first 10 years of operation, and may require a lower gate fee payment by the citizens (economics

							comparison).
6	Beatrice (2014)	Cost Benefit Analysis (CBA) on the Dublin Waste-to Energy project Prepared for the Dublin Authorities	Sustainable Energy Policy Development, U.S	Differentiation, Descriptive Statistics	Renewable Energy, Sustainable Development	Production Theory	The study corroborated the projections by independent energy market experts: the electricity market prices scenarios are within the range of the long term average prices.
7	Beatrice and Jussi (2013)	Municipal Solid Waste Management (MSWM) Problems in Nigeria: Evolving Knowledge Management Solution	Nigeria	Mechanistic process simulations	Poor communication, low personnel morale and waste management.	Desalination	Lack of knowledge about the benefits of waste management, a lack of producer involvement in waste management, and a misapplication of government regulations all contribute to inadequate waste management at the individual, residential, commercial, and industrial levels.

8	Oktyabrskiy, (2016)	A new opinion of the greenhouse gas (GHG) effect	Russia	Physical and chemical processes analysis	Greenhouse gas (GHG) effect, absorption spectrum, and water vapor overtone.	solar radiation absorption	The findings show a strong absorption existence in the solar radiation overtones and combined frequencies of water vapor
9	Rotz, (2017)	Modeling greenhouse gas emissions from dairy farms	United States of America	Mechanistic process simulations, life cycle assessment.	Greenhouse gas, dairy, methane, carbon footprint	life cycle assessment theory	45% of the total greenhouse gas emission of the full farm system, and a bit greater on more-extensive grazing farms the proportion may be is the Enteric emission contribution.
10	Olaoye et al, (2016)	Need for renewable energy mix	Nigeria	Descriptive statistics	Renewable energy, Energy crisis.	Development	The findings show that 3,950MW is the estimated energy from the renewable energy potentials feasible in Nigeria.
11	Nabitz and Hirzel, (2016)	Transposing the requirement of the energy efficiency directive on mandatory energy audits for large	EU-28 member states	Descriptive statistics and comprehensive literature review	Directive Policy Cycle, Energy Management, Energy Audit, Energy Efficiency.	Policy Cycle Analysis theory	The study found empirical evidence that establishes the presence of numerous communalities in the national transpositions of Article 8 EED at a

		company					first glance.
12	Thoma et al, (2013)	Greenhouse gas (GHG) emission from milk production and consumption	United State	Public data and farm operation surveys	Greenhouse gas emission, fertilizer production, crop production, milk packaging	Life cycle analysis theory	The empirical evidence established that there is an approximately 1.6% increase in the estimate of GHG (greenhouse gas) emissions based on the revised global warming potentials
13	Santerio et al, (2013)	Greenhouse gas emission reduction opportunities for concrete pavements	United States of America	The baseline designs with 12 functional units	Global Warming Potential, Industrial Ecology, Carbon Cost effectiveness, Life Cycle Assessment.	Pavement Life Cycle	The findings show a significant greenhouse gas emission reduction is possible, with over half of the scenarios resulting in 10% reductions when compared to unimproved baseline designs.
14	Akhator et al, (2016)	Electricity Generation in Nigeria from Municipal Solid Waste (MSW) using	Nigeria / 2016	Waste-to-Energy Model from Sweden	Incineration, Household waste, Other waste	Endogenous growth theory	According to the findings, Sweden's WTE facilities generated 2.0TWh of

		the Swedish Waste-to-Energy Model					power in 2014 from about 5.7 million tonnes of refuse.
15	Adekomaya and Ojo (2016)	Adaptation Of Plastic Waste to Energy (WTE) Development In Lagos: An Overview Assessment	Nigeria / 2016	Primary and secondary data collection but secondary was more concentrated on	Metals, Plastics, Textiles, Paper, Cardboard, Wood Inerts, etc.	Production Theory	The findings show a high increase in the waste generation in Lagos State and the need of concerted efforts to effectively and sustainably contain the waste.
16	Ogwueleka (2009)	Municipal Solid Waste (MSW) Characteristics and Management In Nigeria	Nigeria / 2009	Open dumping, Incineration, and Recycling.	Waste composition, Food waste, Paper, plastic, glass, metal	Classical theory	According to the data, 60% of the MSW trucks that are available are always out of service, and most metropolitan areas receive insufficient service coverage while rural areas do not receive any collection.

17	Solomon (2016)	Public Health Implications of Poor Municipal Waste Management (MWM) in Nigeria	Nigeria / 2016	Energy Recovery, Waste-Reduction, Reuse, Recycling or composting, Treatment and Disposal.	Arsenic, Lead, Mercury, and Cadmium from Municipal Solid Waste (MSW)	Utility Theory	The study recommended public enlightenment to Nigerian on the risk of allowing children to scavenge and defecate on dumpsites or landfills, and the disposal of dead animals on these dumpsites or landfills. Waste management workers and scavengers should also be encouraged to use personal protective equipment (PPE) at work. Public education on the consequences of indiscriminate defecation and waste disposal within human settlements is also needed. Provision of public toilet facilities in strategic areas for

							Nigerians especially those living without Toilets, will curb indiscriminate defecation.
18	Adeniyi (2014)	Assessment of Solid Waste Management in Samaru Zaria Nigeria	Nigeria / 2014	Self - collection and disposal methods, using pry and secondary sources. Questionnaires, unsanitary method simple random sampling and systematic sampling was employed in data were collection through. descriptive statistical techniques like tabulation, percentages and averages	Waste composition, Food waste, Paper, plastic, glass, metal	Consumption Theory	The findings show that the state government solid waste regulating agencies are non - functional or ineffective. This is due to poor funding of these agencies, bad attitude of waste generators towards waste management, lack of equipment, trained and skilled manpower.

19	Ogunniran (2019)	Harmful Effects and Management of Indiscriminate Solid Waste Disposal on Human and its Environment in Nigeria	Nigeria / 2019	Knowledge of Production Processes, Waste Disposal method, Manufacturing or Industrial method	Industrial wastes materials, gaseous containers from industrial production sites, heavy metals and household refuse from dumpsites near (non-) settlement areas. Liquid, Solid material, Semi-solid or Gaseous material container.	Consumption Theory	The findings recommended urgent implementation of policies that can promote waste generation prevention measures. Safeguarding of human health and environment from unsanitary conditions of indiscriminate solid waste disposal resulting in pollution and diseases.
20	Gary Davidson (2011)	Waste Management Practices	US/2011	Waste management methods 7R methodology eco-efficiency framework	Waste composition, Food waste, Paper, plastic, glass, metal	Kuznets theory	Monitoring results allow for diversion rates, waste reduction, participation, and costs calculation. Regular audits information can foster a revised waste management strategy.

21	Odunola, and Morufu Afolabi(2015)	Industrial Waste Management Practices in Lagos, Nigeria	Nigeria / 2015	Chi-square test study. Primary, secondary data sources, simple systematic random sampling were used.	Waste composition, Food waste, Paper, plastic, glass, metal	Environmental Growth theory Traditional economic theory	96.6% of respondents testified to the production process of all the industries involved waste generation.
						Traditional economic theory	
22	Taiwo and Adewole (2009)	Waste management towards sustainable development in Nigeria	Nigeria / 2009	Refuse disposal and collection management method.	Incineration, Bio Treatment, Recycling, Composting, Secure sanitary landfill, Neutralization.	Endogenous growth theory	The findings identified the waste disposal habit, corruption, inadequate plants and equipment, work attitude, etc. as the banes of effective waste management toward the attainment of sustainable development in Nigeria as a whole. Data from the study shows that the method adopted by these agencies was ineffective, falling short of

							international best practices in waste management and sustainable development. This review results will be useful to researchers, government stakeholders and professionals working in the areas of recycling, material recovery, climate change and waste -to-energy.
23	Oluwaleye (2012)	Proposal for New Waste Management System in Lagos State, Nigeria	Finland (2012)	Qualitative and quantitative research Quantitative approach (questionnaire). Qualitative research (interview) enabling social interaction that make respondents provide their knowledge, understanding, roles, believes & attitudes on waste management	Treatment Plant Waste, Dredged Soil Rubbish, Ashes, Residue, Demotion, Construction Waste, Food Waste, Special Waste, etc.	Bench-marking theory	The findings show that waste minimization or source reduction are always placed on top of the conventional waste management hierarchy. But in reality, source reduction is a necessary precursor to effective waste management, rather than part of it, affecting both

				activities in Finland.			the volume, and nature of the waste, without eliminating waste for disposal.
24	Adenike (2016)	Regenerating Waste to Energy	US / 2016	Landfill Gas Emissions Model; First order decomposition rate equation; Waste management methods; Multi-methods approach	Methane generated annually in the year of the calculation, One year time increment, (year of calculation) - (initial year of waste acceptance), 10% year time increment methane generation rate, (1st year) potential methane generation capacity, Mass of waste accepted in the ith year (Mg) tij = age of the jth section of waste mass Mi accepted in the ith year	Life cycle assessment theory	The study findings estimated that Olushosun Landfill, acclaimed to be the biggest and only currently operating landfill in Lagos State, can generate around 497 million cubic meters (m3) of methane gas from its waste deposits between year 1997 and 2020, with the potential of generating over 5.2 million MWh of electricity over the 23-year period. Similar findings from other landfills in Lagos namely Abule Egba and Solous 1, where an estimated 149 million m3 and 101 million

							m3 methane gas can be cumulatively generated with the potential for producing 1.6 million MWh and 1.1 million MWh of electricity, respectively. Besides, Lagos State has huge potential of recovering significant amounts of methane form the massive waste generated in the State.
25	Olabode et al, (2019)	An Assessment of Material Waste Disposal Methods in the Nigerian Construction Industry	Australia / 2019	A convergent parallel mixed methods, Quantitative and Qualitative Approaches (single enquiry) employed.	Land filling, Open dumping, Incineration, Burning, Recycling	Production Theory	The findings identified lack of regulatory policies and availability of land as responsible for land filling in the study area.
26	Ebikapade and Baird (2017)	Solid Waste Management Trends in Nigeria	UK (2017)	Descriptive Approach used for Data Analysis	Land filling, Open dumping, Incineration, Burning, Recycling	Desalination	This study identified solid waste management (SWM) major challenges or concern in Nigeria

							as; inadequate environmental policies / legislation, poor funding, low level of environmental awareness, corruption, inappropriate technology, and unplanned development.
27	Abila and Kantola (2013)	Municipal Solid Waste Management (MSWM) Problems in Nigeria	Nigeria / 2013	Direct and indirect methods incineration method Landfills method face-to-face communication	Storage, collection, transportation and disposal at dumpsites.	Theory of multivariate distributions	It was found that waste management (MSWM) strategies should be both people and technology centered.
28	Ojo and Bowen (2014)	Environmental and Economic Analysis Of Solid Waste Management Alternatives for Lagos Municipality, Nigeria	Pennsylvania (2014)	Life Cycle Assessment Methodology Waste Reduction Model (Warm)	Vegetables Putrescible Paper Textile, plastic, glass	Policy Cycle Analysis theory	The study generated key findings through a life cycle analysis (LCA). By setting up a material recovery facility at Olusosun landfill, a GHG of 903,493 MTCO2E equivalent to removing 177,155 passenger vehicles from the road or conserving 101 million

							gallons of gasoline yearly can be achieved, when compared with current operations.
29	Olaleye and Richard (2013)	Renewable municipal solid waste pathways for energy generation and sustainable development in the Nigerian	Nigeria / 2013	Energy recovery method	plastics, metals, paper, textile, rubber, inert or miscellaneous.	Life cycle analysis theory	The study discovered a renewed effort to improve this recovery process for organic waste handling and the realisation of its full potentials in a municipal solid waste management.
30	Tariwari and Jasper (2017)	Review on the Environmental Impacts of Municipal Solid Waste (MSW) in Nigeria: Challenges and Prospects	Nigeria (2017)	Recycling, Landfill system, Incineration, Anaerobic digestion and Composting.	Solid Waste Types; Household, Organic, Plastic, Metal and Glass	Pavement life cycle	The findings show that effective, efficient and safe management of MSW that integrates the collective efforts of individuals, local, state and federal governments, as well as the role of other stakeholders, and pressure groups in the private sector are important.

APPENDIX B

The descriptive statistical technique is used to analyze the data and the following results obtained:

Table 4.83. Descriptive Summary of Objective 3 Results (ARDL)

	LOG(GDPC)	LOG(WTE)	CO2	EXC	LOG(FDI)	LOG(GCF)	LOG(LAB)
Mean	7.394468	4.339318	0.597777	149.6606	21.21665	23.99739	2.684883
Median	7.263262	4.333679	0.587523	99.25265	21.18917	23.64689	3.685940
Maximum	7.848970	4.388360	0.873822	531.2015	22.90268	25.02718	5.978633
Minimum	7.048496	4.288979	0.325376	48.96753	19.05813	22.98240	-1.819208
Std. Dev.	0.274093	0.030311	0.170759	120.0366	1.091789	0.635659	2.757666
Skewness	0.499828	-0.055610	-0.045578	1.781252	-0.144698	0.438650	-0.448909
Kurtosis	1.607913	1.602206	1.866957	5.315758	2.058158	1.718454	1.761186
Jarque-Bera	4.528215	3.031220	1.991980	27.83350	1.496677	3.718523	3.608636
Probability	0.103923	0.219674	0.369358	0.000001	0.473152	0.155788	0.164587
Sum	273.5953	160.5548	22.11775	5537.441	785.0160	887.9034	99.34067
Sum Sq. Dev.	2.704576	0.033075	1.049709	518716.7	42.91208	14.54624	273.7700
Observations	37	37	37	37	37	37	37

5

6

7 Correlation Analysis

8 This subsection contains the correlation analysis of the variables used in this study

Correlation analysis

	GDPC	WTE	CO_2	EXC	FDI	GCF	LAB
GDPC	1.000000						
WTE	-0.688459	1.000000					
CO2	0.097068	-0.055892	1.000000				
EXC	-0.156136	0.450134	0.405888	1.000000			
FDI	0.800093	-0.537739	-0.074790	-0.355783	1.000000		
GCF	0.920780	-0.561481	0.058165	-0.073131	0.641826	1.000000	
LAB	0.917537	-0.699216	-0.045888	-0.271874	0.720917	0.869903	1.000000

Unit Root Test

H_0: ʒ = 0 (the series is none stationary)

H_0: ʒ < 0 (the series is stationary)

Unit root Test

31

32

33

ARDL Cointegrating And Long Run Form

Dependent Variable: LOG(GDPC)

Included observations: 33

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(GDPC(-1))	0.651380	0.078252	8.324082	0.0036
DLOG(GDPC(-2))	0.374220	0.054480	6.868926	0.0063
DLOG(GDPC(-3))	-0.154730	0.056950	-2.716935	0.0727
D(WTE)	-0.005369	0.003482	-1.541992	0.2207
D(WTE(-1))	0.006580	0.001769	3.720279	0.0338
D(WTE(-2))	0.009526	0.002087	4.564015	0.0197
D(CO2)	0.192047	0.052596	3.651369	0.0355
D(CO2(-1))	-0.334664	0.048470	-6.904527	0.0062
D(CO2(-2))	-0.038059	0.038402	-0.991067	0.3947
D(CO2(-3))	-0.500872	0.028022	-17.874205	0.0004
D(EXC)	-0.000130	0.000080	-1.629358	0.2017
D(EXC(-1))	0.000499	0.000090	5.552107	0.0115
D(EXC(-2))	-0.000578	0.000082	-7.059868	0.0058
D(EXC(-3))	-0.000138	0.000079	-1.752472	0.1780
DLOG(FDI)	0.002098	0.006179	0.339610	0.7565
DLOG(FDI(-1))	-0.100048	0.010191	-9.817262	0.0022
DLOG(FDI(-2))	-0.034772	0.008174	-4.254123	0.0238
DLOG(FDI(-3))	-0.062857	0.009242	-6.801021	0.0065
DLOG(GCF)	0.119165	0.020012	5.954712	0.0095
DLOG(GCF(-1))	-0.050982	0.019819	-2.572411	0.0823
DLOG(GCF(-2))	-0.048396	0.018709	-2.586821	0.0813
DLOG(GCF(-3))	-0.113811	0.017679	-6.437822	0.0076
D(@TREND())	0.001364	0.001082	1.259748	0.2968
CointEq(-1)	-1.798284	0.074853	-24.024255	0.0002

Cointeq = LOG(GDPC) - (-0.0290*WTE + 0.3557*CO2 + 0.0002*EXC +

0.1209*LOG(FDI) + 0.2112*LOG(GCF) + 1.7321 + 0.0008*@TREND)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
WTE	-0.028998	0.002754	-10.528521	0.0018
CO_2	0.355729	0.035119	10.129337	0.0020
EXC	0.000245	0.000087	2.812518	0.0672
LOG(FDI)	0.120920	0.006562	18.428044	0.0003
LOG(GCF)	0.211187	0.010424	20.259911	0.0003
C	1.732115	0.228756	7.571888	0.0048
@TREND	0.000758	0.000611	1.241572	0.3026

ARDL Bounds Test

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	30.7805	5

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.75	3.79
5%	3.12	4.25
2.5%	3.49	4.67
1%	3.93	5.23

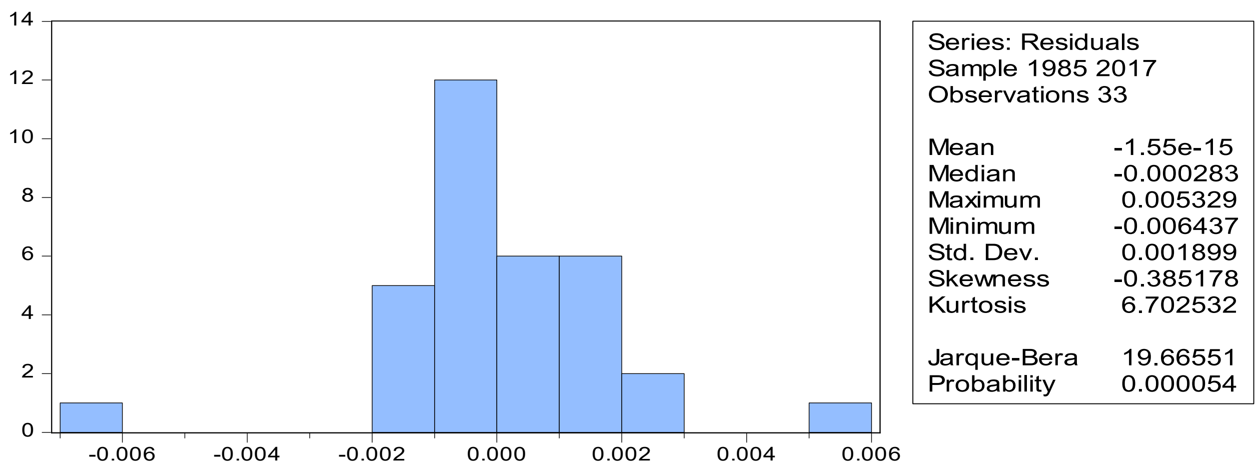
Pairwise Granger Causality Tests

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LOG(WTE) does not Granger Cause LOG(GDPC)	35	1.68145	0.2032
LOG(GDPC) does not Granger Cause LOG(WTE)		2.33306	0.1144
CO_2 does not Granger Cause LOG(GDPC)	35	0.06921	0.9333
LOG(GDPC) does not Granger Cause CO_2		0.09195	0.9124
EXC does not Granger Cause LOG(GDPC)	35	4.03318	0.0281
LOG(GDPC) does not Granger Cause EXC		1.59245	0.2201
LOG(FDI) does not Granger Cause LOG(GDPC)	35	4.95745	0.0138
LOG(GDPC) does not Granger Cause LOG(FDI)		0.95664	0.3956
LOG(GCF) does not Granger Cause LOG(GDPC)	35	0.74598	0.4829
LOG(GDPC) does not Granger Cause LOG(GCF)		12.0085	0.0001
LOG(LAB) does not Granger Cause LOG(GDPC)	35	4.06111	0.0275
LOG(GDPC) does not Granger Cause LOG(LAB)		0.31405	0.7329
CO_2 does not Granger Cause LOG(WTE)	35	0.29673	0.7454
LOG(WTE) does not Granger Cause CO_2		0.32262	0.7267
EXC does not Granger Cause LOG(WTE)	35	1.74319	0.1922
LOG(WTE) does not Granger Cause EXC		0.24672	0.7829
LOG(FDI) does not Granger Cause LOG(WTE)	35	2.61860	0.0895
LOG(WTE) does not Granger Cause LOG(FDI)		1.14140	0.3329

LOG(GCF) does not Granger Cause LOG(WTE)	35	1.65200	0.2086
LOG(WTE) does not Granger Cause LOG(GCF)		2.08659	0.1418
LOG(LAB) does not Granger Cause LOG(WTE)	35	7.78690	0.0019
LOG(WTE) does not Granger Cause LOG(LAB)		0.10750	0.8984
EXC does not Granger Cause CO_2	35	1.21739	0.3102
CO_2 does not Granger Cause EXC		0.40385	0.6713
LOG(FDI) does not Granger Cause CO_2	35	0.34413	0.7116
CO2 does not Granger Cause LOG(FDI)		4.24854	0.0237
LOG(GCF) does not Granger Cause CO2	35	0.37892	0.6878
CO2 does not Granger Cause LOG(GCF)		0.07170	0.9310
LOG(LAB) does not Granger Cause CO2	35	1.52008	0.2351
CO_2 does not Granger Cause LOG(LAB)		0.09118	0.9131
LOG(FDI) does not Granger Cause EXC	35	0.23183	0.7945
EXC does not Granger Cause LOG(FDI)		3.22385	0.0539
LOG(GCF) does not Granger Cause EXC	35	2.64791	0.0873
EXC does not Granger Cause LOG(GCF)		2.42614	0.1055
LOG(LAB) does not Granger Cause EXC	35	0.79660	0.4602
EXC does not Granger Cause LOG(LAB)		0.82946	0.4460
LOG(GCF) does not Granger Cause LOG(FDI)	35	3.29280	0.0510
LOG(FDI) does not Granger Cause LOG(GCF)		8.97699	0.0009
LOG(LAB) does not Granger Cause LOG(FDI)	35	2.05532	0.1457
LOG(FDI) does not Granger Cause LOG(LAB)		0.71928	0.4953
LOG(LAB) does not Granger Cause LOG(GCF)	35	5.31054	0.0106
LOG(GCF) does not Granger Cause LOG(LAB)		0.79856	0.4593

Normality Test



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	3.641744	Prob. F(2,1)	0.3475
Obs*R-squared	29.01617	Prob. Chi-Square(2)	0.0000

79

80

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.572116	Prob. F(29,3)	0.8208
Obs*R-squared	27.94676	Prob. Chi-Square(29)	0.5208
Scaled explained SS	0.658542	Prob. Chi-Square(29)	1.0000

APPENDIX B

Table 4.92. Post Estimation Technique

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.048748	Prob. F(2,10)	0.1796
Obs*R-squared	9.591589	Prob. Chi-Square(2)	0.0083

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.128772	Prob. F(19,13)	0.4203
Obs*R-squared	20.54597	Prob. Chi-Square(19)	0.3624
Scaled explained SS	2.623625	Prob. Chi-Square(19)	1.0000

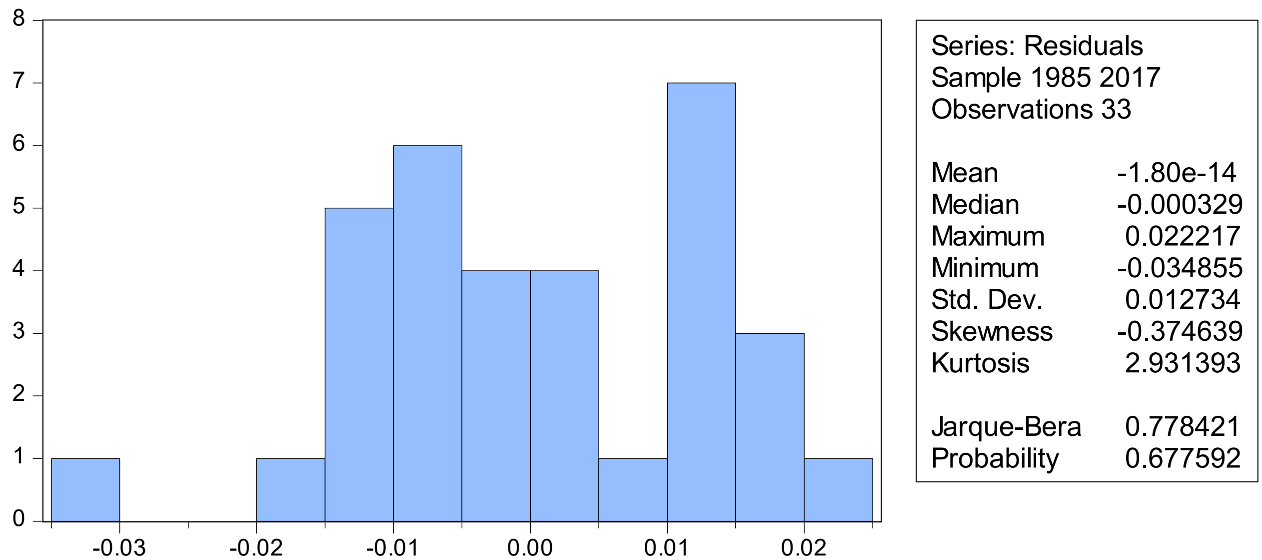
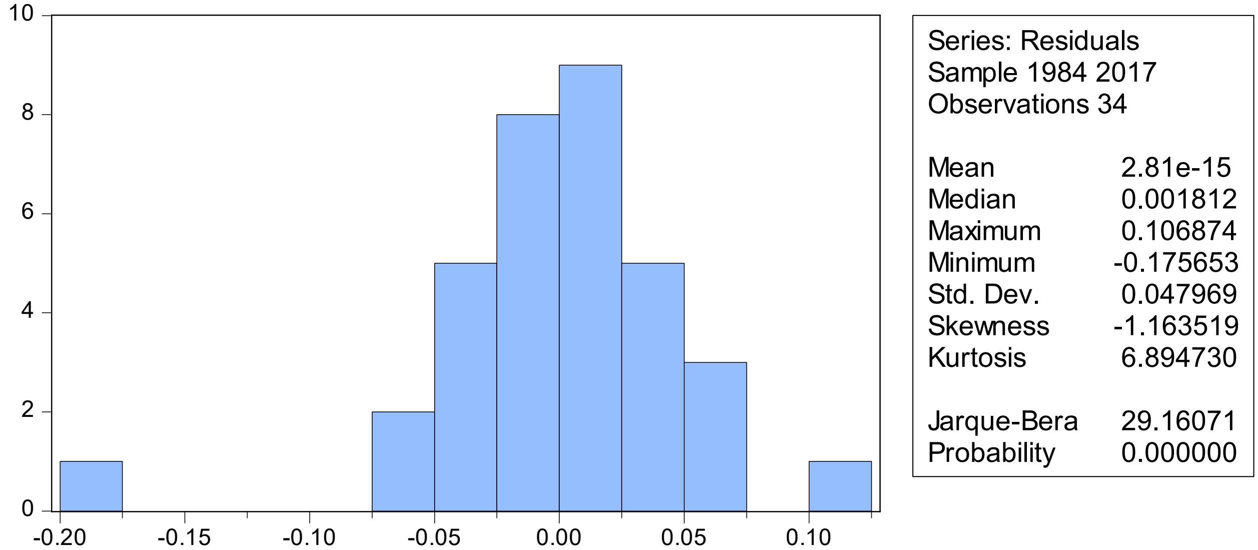


Table 4.98. Breusch-Godfrey Serial Correlation LM Test



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	3.391068	Prob. F(2,12)	0.0680
Obs*R-squared	12.27723	Prob. Chi-Square(2)	0.0022

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.277437	Prob. F(19,14)	0.3245
Obs*R-squared	21.56248	Prob. Chi-Square(19)	0.3066
Scaled explained SS	10.77534	Prob. Chi-Square(19)	0.9312

APPENDIX C

1.0 QUESTIONNAIRE

Waste to Energy (WtE) Survey Research

(A Survey of Waste Management in Targeted Locations)

Dear Sir/Ma,

This questionnaire is designed to obtain information on the topic above. It is a PhD research project in Department of Energy Economics, at the Centre for Petroleum, Energy Economics and Law, University of Ibadan, Ibadan, Oyo State, Nigeria. I assure you that the information provided will be used strictly for academic purpose and kept confidential. Kindly complete the blank spaces and put marks in the appropriate boxes as applicable. Thank you.

Engr. Opeyemi Amusan (May 2019)

SECTION A: BIOGRAPHICAL INFORMATION

INSTRUCTION: Please tick as appropriate										
S/N	**Question**						**Response/Options**			**ANS**
1	**Gender**						Male			☐
							Female			☐
2	**Age**									
<18yrs	**25-29yrs**	**30-34yrs**	**35-39yrss**	**40-44yrs**	**45-49yrs**	**50-54yrs**	**55-59yrs**	**60-64yrs**	**65-69yrs**	**70+**
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Specific Age			**Age as at last birthday**			☐			
3	**Marital Status**									
	Married	**Single**	**Divorced**	**Separated**	**Others**					
	☐	☐	☐	☐	☐					
4	**Highest Level of Education**									
	No formal Education	**Primary**	**Secondary**	**Tertiary**	**Others**					
	☐	☐	☐	☐	☐					
5	**Household size**						Nos of Male			☐
							Nos of Female			☐

6	**Type of household**							
	1-Room Apartment		**Flat**		**Bungalow**	**Duplex**	**Terrence**	**Others**
	▭		▭		▭	▭	▭	▭
6	**Monthly Income**							
	<18k	**18 – 30K**	**31-40K**	**41-50K**	**51-70K**	**71 – 90K**	**91-100K**	**101+**
	▭	▭	▭	▭	▭	▭	▭	▭
	Specific Income				₦:			
7	Do you have any other occupation apart from your regular work (are you a business owner?)				Yes			▭
					No			▭
	If yes please mention the business							

SECTION B: WASTE TO ENERGY

INSTRUCTION: Please tick as appropriate			
S/N	**Question**	**Response/Options**	**Answer**
1	Types of Waste Disposed/Generated	Domestic Solid Waste	▭
		Industrial Solid Waste.	▭
2	Categories of Waste:	Plastic	▭
		Paper	▭
		Agric/Food	▭
		Other Wastes	▭
3	Waste disposal options available:	Refuse Bins	▭
		Dumpsite	▭
		Private Collection	▭
		Indiscriminate Dumping	▭
		Specified Dump point	▭
4	Do you separate your waste at source:	Yes	▭
		No	▭
	If No, why?	Time wasting/Not Necessary	▭
		No Provision/Encouragement	▭
	If Yes, why?	Helps waste management	▭

		Others	
5	**What is your perception on waste management & separation**		
	Perception on waste separation:	Right	
		Wrong	
		Undecided	
	Perception on land fill/open & Indiscriminate dumping:	Right with minimal consequences	
		Wrong with grate Consequences	
		Undecided.	
6	**Location/source of waste**		
	How far is your house & work to dumpsite:	Very Close (< 1km)	
		Not Far (1-3km)	
		Far (>3km).	
7	**Perception on waste management & challenges**		
	How effective is waste management in your area & why? :	Effective + Need Improvement	
		Not Effective + Require	
		Overhaul	
		Undecided	
	Why?	Inadequate Funding	
		Lack of Personnel	
		Lack of Equipment	
		Technological Constraints.	
8	What are the waste management styles in your area?	PSP	
		LAWMA/Government Waste Management	
		None Open Disposal.	

9	**Waste generation by rank: (1) Lowest to (5) Highest.**					
	Rank	**1**	**2**	**3**	**4**	**5**
	Plastic;					
	Food/Agric;					
	Paper;					

	Waste/Hazardous;						
	Sweepings.						
10	Are you willing to pay for waste management / WTE in accordance with polluters' pay principle?	Yes, Because health is wealth					☐
		No, I prefer damn the consequence than pay.					☐
11	How much do you spend on electricity (DISCOS/NEPA) per month?	₦					
12	How much do you spend monthly on generator (petrol/diesel)?	₦					
13	Where WTE/waste management should be done?	Land Fills/Dumpsites					☐
		Outskirt					☐
		Within the City/Residence					☐
	Strongly Agree (SA), Agree (A), Disagree, (D), Strongly Disagree (SD)	**SA**	**A**	**D**	**SD**		
14	Waste MGT is very challenging in my Area.						
15	I do experience health issues/ pollution (water, air or land) from waste in my area?						
16	What are the health or hazard issues experienced from waste?						
17	Do you farm close to dumpsites?	Yes					☐
		No					☐
	Why?						
18	Mention some electrical appliances and equipment you require electricity to power.						
	Television	Refrigerator	Air Condition	Fan	Electric Cooker	Iron	Others specify
	☐	☐	☐	☐	☐	☐	
19	What type of waste is common in your	Domestic Solid Waste	Industrial Solid Waste.				

	area?		☐		☐
20	Would you like these wastes to be used to generate electricity (24/7) for your household and work?	Yes			☐
		No			☐
21	Will you support & encourage waste-to-energy project if introduced to save both waste & electricity problem in your area?	Yes			☐
		No			☐
	Why?				
22	Where would you prefer WTE plant to be built in your area?				
	Anywhere / Close to Dumpsite	Far from my Area	Dumpsite	At the center of the city	Others (specify)
	☐	☐	☐	☐	
23	Will you be willing to pay the money you use for DISCOS/NEPA generator bills to have a consistent electricity (24/7) from WTE?	Yes			☐
		No			☐
24	How much do you pay for waste disposal?	₦			
25	Do you reuse, recover & recycle your waste?	Yes			☐
		No			☐
	Why?				
26	Do people work in waste management facilities in your area?	Yes			☐
		No			☐
27	Average amount spent in a month (Consumption)	₦:			
28	Average amount saved in a month (Savings)	₦:			

29	What are the challenges you face in managing your waste?				
30	Do you experience any health issues/ pollution (water, air, or Land) from waste in your area?	Yes			☐
		No			☐
	If yes please specify				
31	What are the health or hazard issues experienced from waste?				
32	How many bags of waste do you generate in your household per week?	1-2 bag	2-4 bags	> 4 bags	1 or more drums
		☐	☐	☐	☐
33	Waste management helps in reducing the level of pollution in my area.	SA	A	D	SD

2.0 Research Work plan And Milestones

The objectives spelt out for this Doctoral degree (PhD) research are intended to be achieved within the space of 3 years (36M). The breakdown is given below:

Table 2.0: Research Workplan

	ACTIVITY	6M	12M	18M	24M	30M	36M
1.	PhD Course Works / Proposal / Literature	*	*				
2.	Pre-field Seminar (Jan. / Feb. 2019) / Conversion Exams (Feb. / Mar. 2019)		*	*			
3.	Field Work / Data Collection (Feb - Nov. 2019)		*	*	*		
4.	Data Classification / Data Analysis / Post - Field Seminar / Workshop (Dec. 2019)		*	*	*		
5.	Publications / Research Stay Abroad / Thesis Reg., Writing & Submission of PhD Dissertation		*	*	*	*	*
6.	PhD Dissertation Defense / Viva (Jun. 2020)					*	*
7.	PhD Convocation (Nov. 2020)						*

APPENDIX D

2.1 RESEARCH PROGRAM MILESTONES:

1 **Dec. 2017 - Dec. 2018: Course Works; Proposal Development; Conference Attendance**

- 17 Stipulated Courses & Examinations; Literature Review
- Updated PhD Proposal (Application to the Current Version)
- Attended 9 Conferences - 5 At Home and 4 Abroad
- At Home: CPEEL/ANSOLE, NAEE/IAEE, CESD, AIF,SW (Nigeria
- Abroad: FOOD2030, Tropentag Ghent, GAEF, DAAD (Europe)

2 **Jan. 2019 - Dec. 2019: Pre-field; Conversion Exam; Fieldwork; Post-field; Conference**

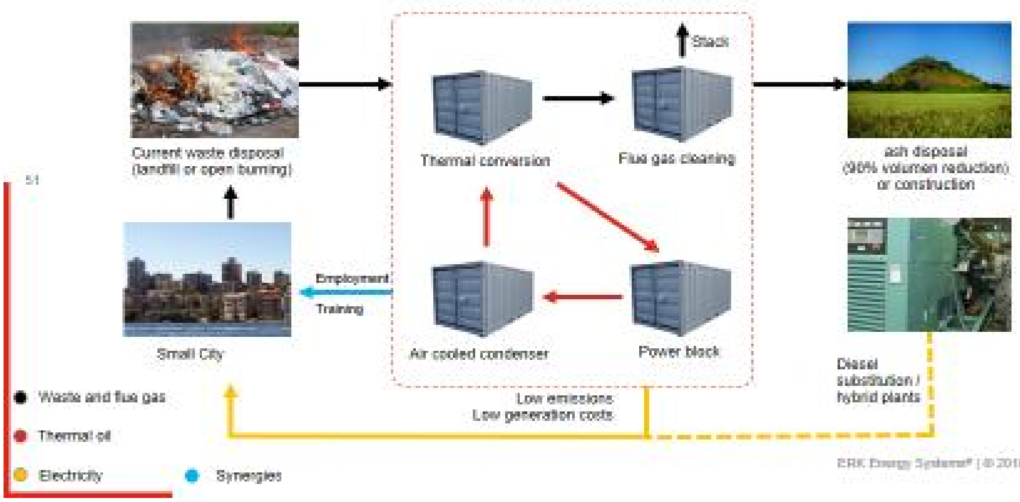
- Pre-field Seminar (January / February 2019)
- Conversion Examination (February / March 2019)
- Fieldwork / Data - Collection/ Classification/ Analysis (February-November 2019)
- Conference Attendance-NAEE/IAEE (NG), WACEE / Experts Summits (EU & GH)
- Waste/WtE Mgt Training / Stakeholders Workshops (Sept @NG &Nov @GH 2019)
- PhD Internship (Energy Economist & Environmental Analyst) at Ghana Energy Commission, Accra, Ghana
- Post-field Seminar (December 2019 – now slated for January 2020)

3 **Jan. 2020 - Nov. 2020: Publications/ Research Stay Abroad/ Thesis Write-up & Defense**

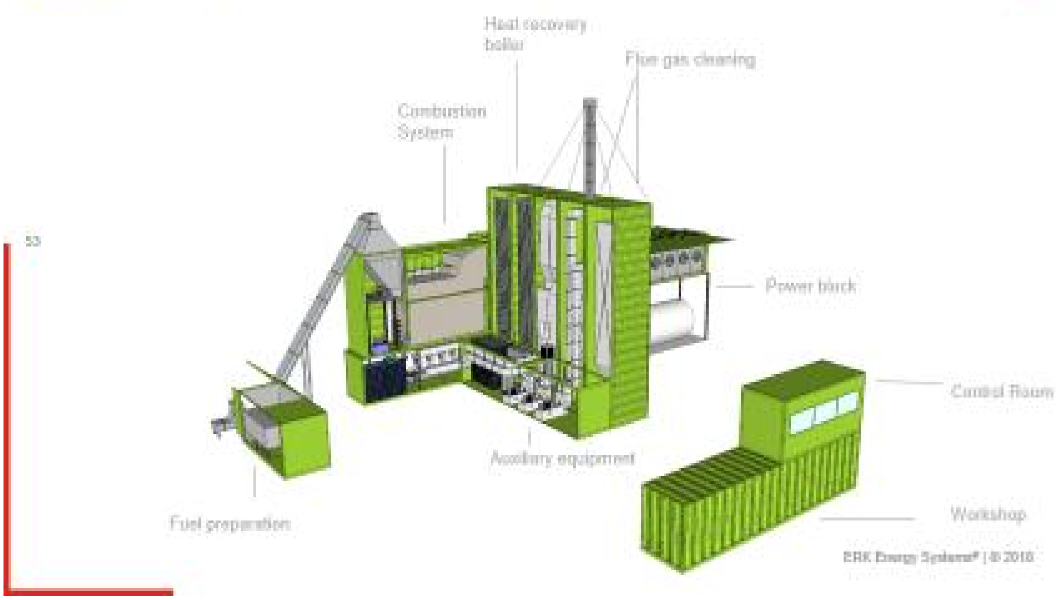
- PhD Post-field Addendum / Abstract / Thesis Title Registration (Jan-March 2020)
- Research Publications: Elsevier / Springer / Lambert Academic Publishing
- Research Stay Abroad (January - June 2020): 3–6 months [Ghana Energy Commission / HEED-Africa Fellowship]
- Conference Attendance: NAEE/IAEE/Tropentag & Policy Brief Publication
- Data Analyses, Writing & Submission of Thesis (Jan - May 2020)
- PhD Thesis Defense (July 2023 actual) & PhD Convocation (November 2023)

Contacts with Supervisors: 2.Weekly (Meet); Monthly (Report); Quarterly (Milestone)

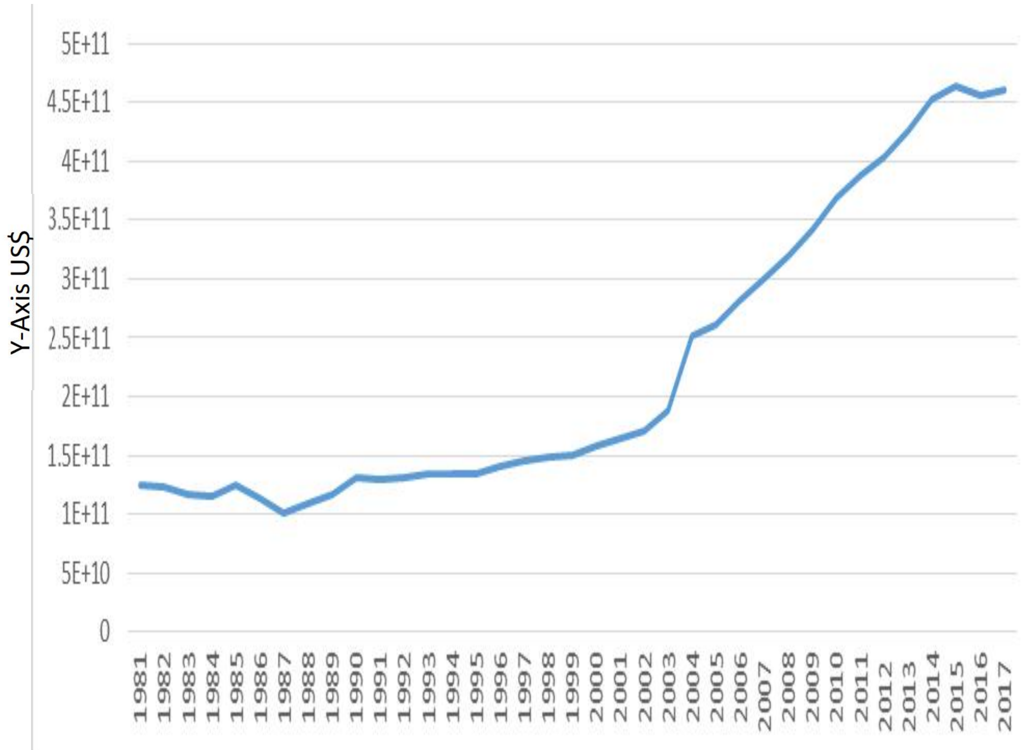
ReGen: 330KW CONTAINER POWER PLANT-CONCEPT



ReGen CONTAINER POWER PLANT - ARRANGEMENT



APPENDIX D



X-Axis Years

Figure 1.1. Trend Analysis of Real GDP (Source: Author's Computation)

APPENDIX D

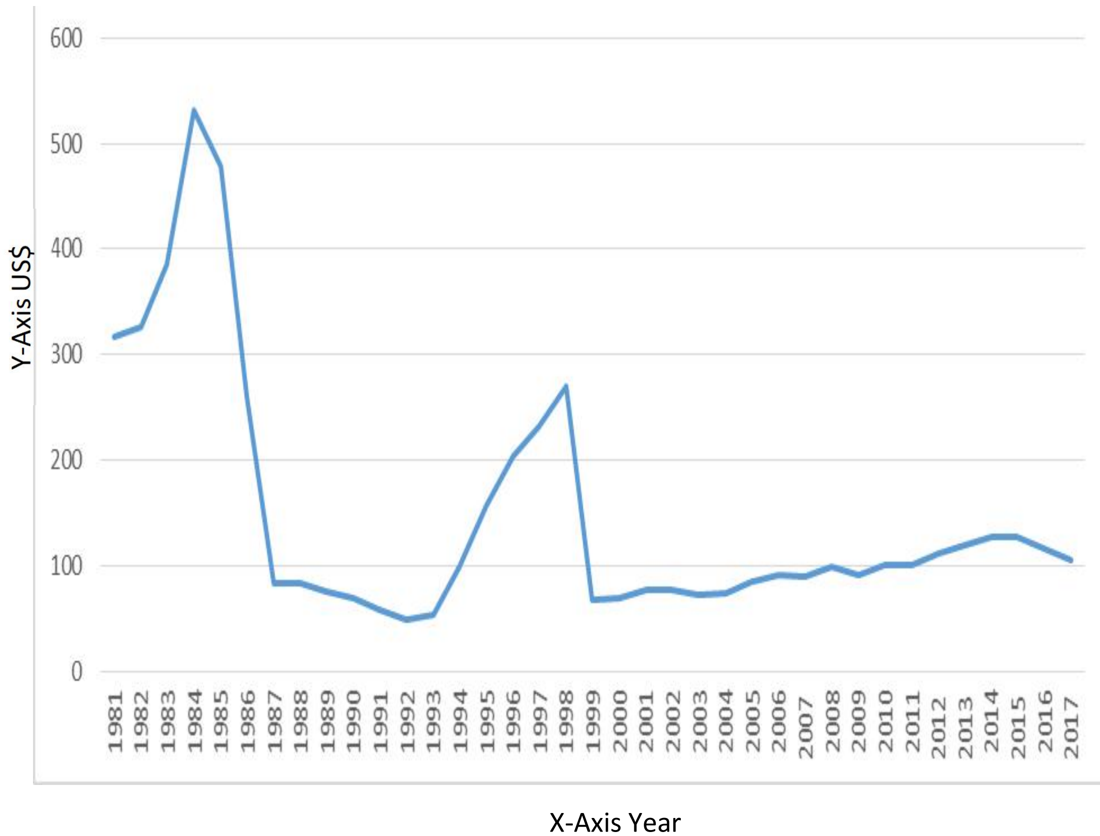


Figure 1.2. Trend Analysis of Real E. Exchange rate (Source: Author's Computation)

APPENDIX D

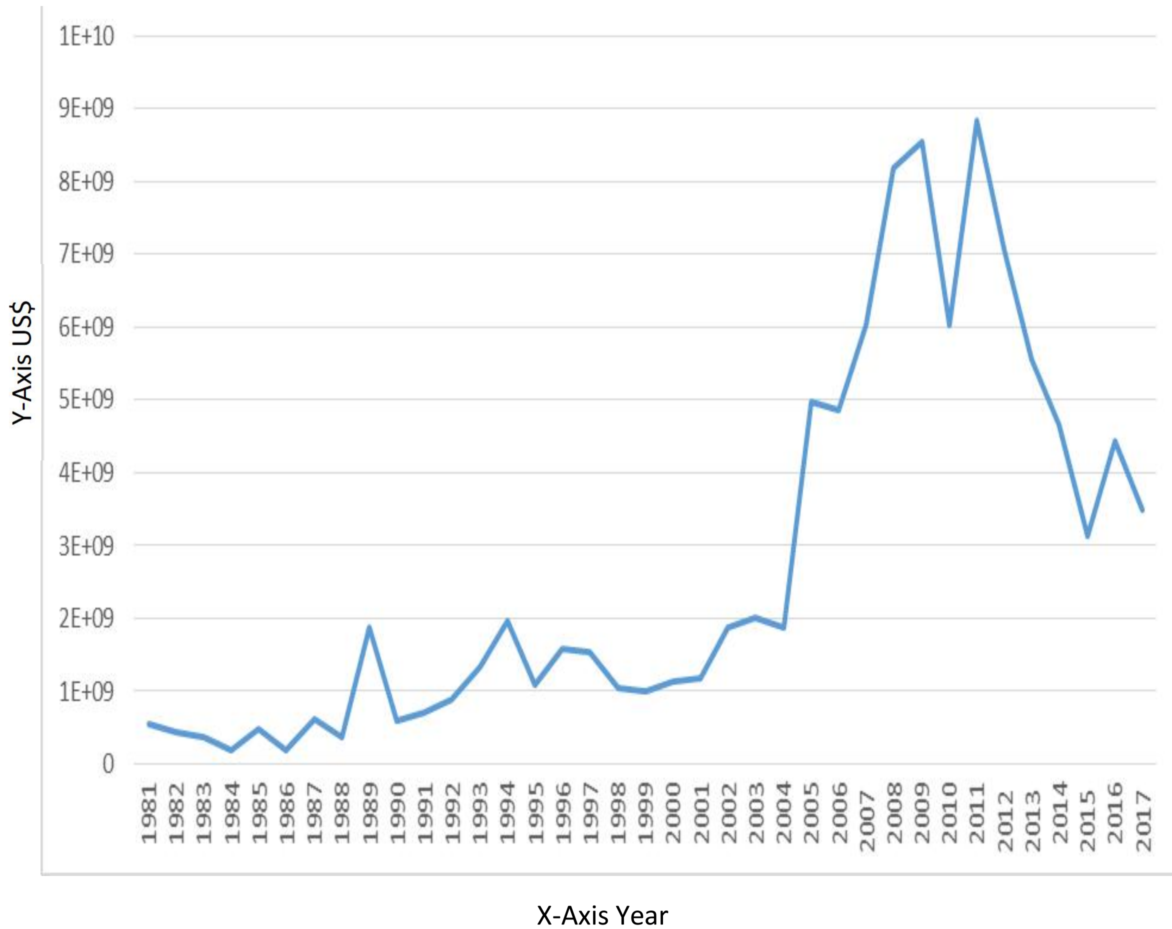


Figure 1.3. Trend Analysis of FDI (Source: Author's Computation)

APPENDIX D

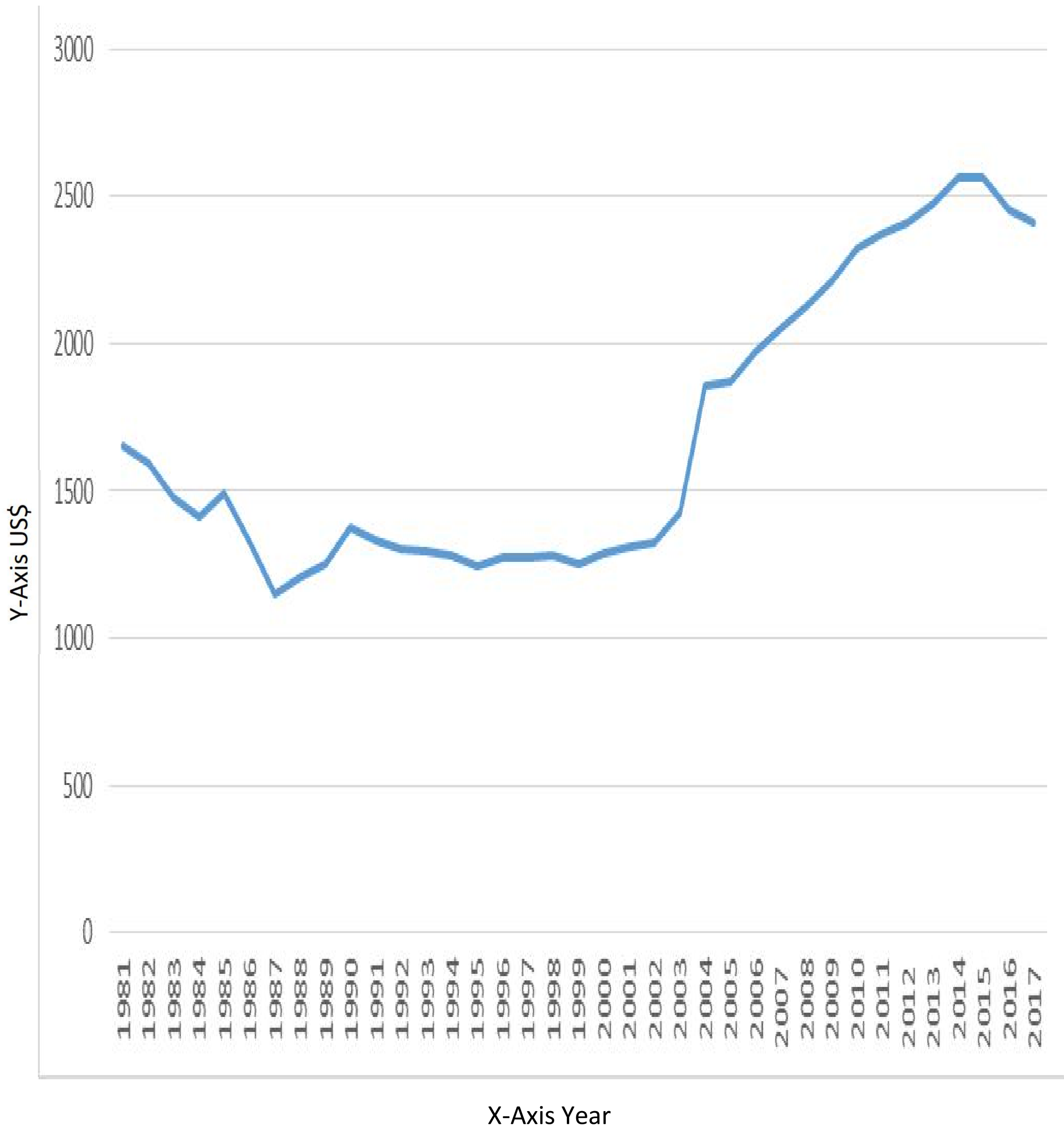


Figure 1.4. Trend Analysis of RGDP per Capita (Source: Author's Computation)